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SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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Sensitivity and Motion-Capturing Ability of Television Camera Tubes

By R. G. NEUHAUSER

The sensitivities of various camera tubes are determined in terms of the illumination levels required for both standard and nonstandard television scanning rates. For convenience, these values are given in terms of equivalent ASA film exposure index values to facilitate the use of a common exposure meter to determine scene light or iris settings.

The effective rapidities of response of various camera tubes are also evaluated in terms of the ability to stop motion. This factor is evaluated both from the standpoint of deriving intelligence from the signal and from the standpoint of the esthetics of the picture, i.e., absence of negative image or "long-tail" carry-over of signal. The effects of overexposure or of underexposure on the speed of response of different camera tubes is also illustrated.

This paper discusses television camera tube sensitivity and the ability of television camera tubes to capture motion through a comparison with these properties in photographic film. In photographic film, the sensitivity and ability to capture motion are interrelated, since the speed of the shutter, which determines the motion-capturing ability of the film camera, may be changed to trade increased scene light for better motion-capturing ability. In television camera tubes, on the other hand, these properties are not directly interrelated. The sensitivity of a camera tube can be expressed simply in terms of the amount of light required to produce a properly exposed picture. This paper shows how the light requirements for proper camera tube exposure can be related to the familiar film speed index numbers. The ability of a camera tube to capture or arrest motion is determined not by a shutter, but by the television scanning standards and by the camera tube carry-over of images from field to field.

An ASA Index for Camera Tubes

If the TV camera tube can be assigned an index similar to the familiar ASA film speed or film exposure index, a common denominator can be established and the relative sensitivities of the camera tube and film can be compared in absolute terms. The advantage of a system that designates camera tube sensitivity in such a way is that it affords an easy method for determining the proper exposure or lighting conditions for TV cameras. Foot-candle meters, conversion tables for lens stop numbers and tabulated information on the amount of light required on the face of the camera tube are scarce and are rarely assembled in one place. However, millions of photographic exposure meters are in the hands of people who know how to use them. Built into these meters are both a correction factor for average scene content and a computer that will readily determine the proper exposure for a camera having a sensitivity specified in terms of a standard index. Thus, if the operator of a closed-circuit television system knows the exposure index of the camera tube, he can set up lighting conditions and camera lens openings with a fair degree of accuracy by the use of the familiar exposure meter.

This system may not be especially useful for broadcast television because established procedures and monitor equipment are available to the lighting engineer for reference when he is shooting a scene. Moreover, the TV camera is not secretive about its viewpoint. It readily displays, either on a monitor kinescope, on the waveform monitor or on the signal current meter, a graphic indication of the relative exposure of the camera. This information is easily interpreted by the skilled operator. However, these aids are not necessarily available to the operator of the closed-circuit television system. The simple instrumentation afforded by an exposure meter can be an immeasurable aid in determining whether the proper lighting levels are obtainable in the wide variety of situations that are encountered in the use of closed-circuit TV systems.

Similarity Between Film and TV Processes

The exposure of a film is the product of the light intensity and the duration of the exposure and is usually expressed in meter-candle-seconds. The sensitivity of the film, which is indicated by the ASA exposure index, defines the exposure required for the particular film, and any combination of light level and exposure time that exposes the film to the required quantity of light can be used.

The camera tube, on the other hand, is usually thought of as a continually exposed device producing a continuous video signal. However, a striking parallel between the two becomes apparent when the process of signal generation in a camera tube is understood. Television camera tubes (with one exception, the image dissector) are storage-type tubes. These tubes store images in the form of a charge on the target for the duration of one television field. The amount of this charge at each point on the target is proportional to the product of the intensity of light and the time of exposure between successive scans of that spot by the scanning beam which removes the charge. Thus, each television field is essentially a complete process equivalent to a single film exposure. The "shutter speed" of the television system is its field rate. For a television system, the field rate is fixed and can be changed only by changing the scanning system frequencies or standards, or by interrupting the light at some time during each field. The light can be interrupted after the initial exposure because the storage element of the camera tube will integrate all of the charge developed by the light

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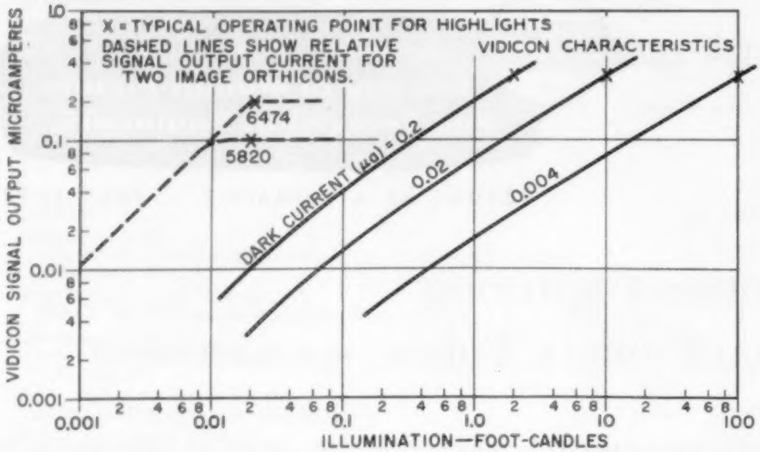

Fig. 1. Typical light transfer characteristics of several camera tubes showing the illumination required on the tube faceplate.

and store it until the scanning beam removes the charge. This method is employed in TV cameras which are used to reproduce motion-picture film. Here the required quantity of light is applied to the camera tube during each scanning interval, and the film is pulled down to a new position during the time the light is cut off. In such a system, the light intensity and exposure time also can be varied, so long as the product of both remains a constant.

Because of the similarity between the actions of a storage-type camera tube and a film camera, an accurate parallel can be drawn between the exposures they require. As shown in Fig. 1, the light values required for a camera tube are commonly expressed as the intensity of light in foot-candles that is continuously required on the faceplate of a camera tube operating in a standard TV camera system. For the vidicon, the specific current output is significant as indicated by the abscissas. For the image orthicon, in most applications the only point that has any numerical significance is the value of the highlight faceplate illumination relative to that required to reach the knee of the characteristic. In either case the crosses indicate the highlight illumination that has been found by experience to be required for proper exposure, either relative to the peak-to-peak signal output current (the significant factor in vidicons) or relative to the knee (the significant factor in image orthicons). These show the proper values for recommended highlight exposure for best picture performance. Light requirements for film exposure to produce a desired film density, as shown in Fig. 2, are expressed in terms of meter-candle-seconds.

Quantity of Light for Each TV Field

The first step in the coordination of these data is to express the light required for the camera tube in terms of the quantity of light necessary to expose properly a single complete television image. This quantity of light is equal to the intensity of the light times the exposure time of each complete image. A single television image, or frame, comprises two fields of scanning lines. The lines of one field fall between those of the other field to compose the complete TV frame. Experience has shown that the TV camera tube usually removes most of the information from a stored charge image in 1/60 sec. This is illustrated by a comparison of Fig. 5 with Figs. 4A and 4B. Theoretically, this removal of information would take place in the frame time of 1/30 sec. However, the scanning beam is not fine enough to scan the one interlaced raster precisely with no beam overlap into the other field. Because the beam removes almost all the information from both fields each time it scans the target, a complete TV picture is essentially formed each 1/60 sec. Therefore, if the light intensity is multiplied by 1/60 sec, the exposure of the camera tube for each field can be expressed in terms of foot-candle-seconds. This value is multiplied by 10.76 to convert it to meter-candle-seconds.

The next relationship which must be established is that between the highlight operation point on the camera-tube light-transfer-characteristic curve and a similar operating point on the optical density log-exposure curve for film. This relationship can be established by determining the actual highlight exposure that results when a film is exposed on the basis of light meter readings and its ASA exposure index.

ASA Exposure Index for Camera Tube

Film sensitivity is determined by the minimum quantity of light which must be incident upon the film to result in good reproduction of the low-light portions of the image as shown by point C on Fig. 2. Point B represents the highlights of a "normal" scene when the low-lights produce an exposure E. The exposure E is defined by ASA standards as the exposure value at the point on the D-log E curve of the film at which the slope of the D-log E curve (angle a in Fig. 2) is 0.3 of the slope of the average between this point and a point B removed from it by a log-exposure range of 1.5 (angle b).

ASA exposure index values of film are by definition $1/4E$. Exposure meters which are designed to ASA standards and which use these film exposure index numbers are calibrated, on the basis of the "normal" scene, to produce a film exposure that will be centered considerably above this lower portion of the D-log E curve for the film. In this way, some latitude of exposure is allowed at each end of the film characteristic curve. The usual location of the highlights (E_H) of a "normal" scene on this exposure curve will be approximately log 2.1 above this E value when exposed using an exposure meter. The highlight of this scene produces on the film approximately 125 times the quantity of light required to expose the film to point E (see Appendix).

Highlight exposure E_H, then, is related to the ASA exposure index number in the following manner:

$$E = \frac{E_H}{125} \tag{1}$$

$$\text{ASA exposure index} = \frac{1}{4E} = \frac{1}{4\left(\frac{E_H}{125}\right)} = \frac{31.2}{E_H} \tag{2}$$

Highlight exposure for a camera tube is equal to the faceplate illumination in foot-candles (I_{fp}) times the equivalent shutter speed or field time (T_f) in seconds. Multiplication of this value by 10.76 converts it to meter-candle-seconds. Thus, the ASA exposure index for highlight exposure for a television camera tube is

$$E_H = I_{fp} \times T_f \times 10.76 \text{ meter-candle-seconds} \tag{3}$$

$$\text{ASA} = \frac{31.2}{I_{fp}T_f 10.76} = \frac{2.9}{I_{fp}T_f} \tag{4}$$

For example, an RCA-5820 image orthicon, operating in a standard broadcast system with a field rate of 1/60 sec, requires a highlight illumination of 0.01 foot-candle to reach the knee. The equivalent ASA exposure index is therefore:

$$\text{ASA} = \frac{2.9}{0.01 \times \frac{1}{60}} = 17{,}400$$

When the 5820 is operated at a higher light level (as is common practice) with the highlights exposed 2 lens stops above

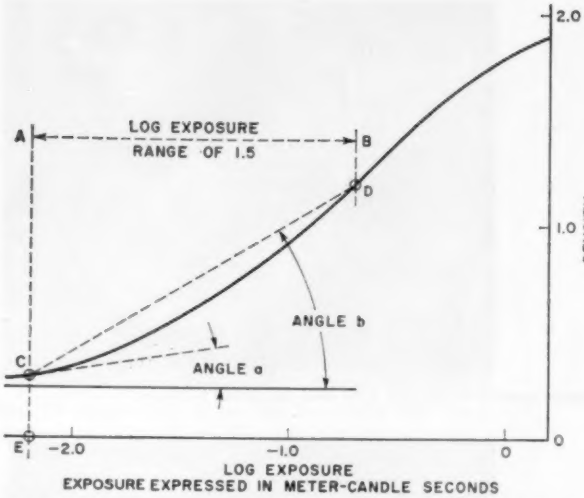

Fig. 2. Typical *D*-log *E* curve of film as used to determine ASA exposure index ratings.

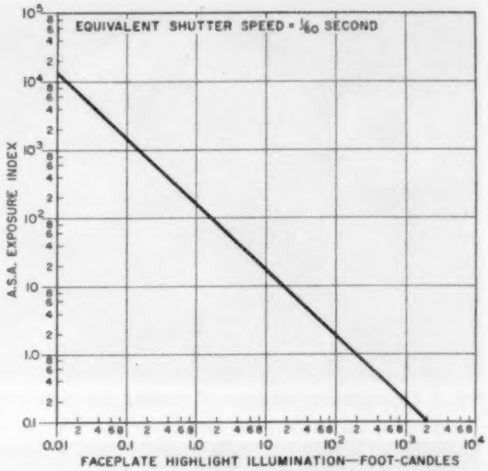

Fig. 3. ASA exposure index values vs. faceplate illumination for camera tubes operated on U. S. broadcast scanning standards (equiv. shutter speed 1/60 sec).

the knee (highlight illumination 0.04) the ASA exposure index will be 4350. The ASA exposure index versus the faceplate illumination required for camera tubes in a system operating on U.S. broadcast standards is shown on Fig. 3. These exposure indexes are used to determine light levels or the appropriate lens stop in the same manner as film exposure index values. The shutter speed setting on the exposure meter computer must be set to 1/60 sec, the field time of the television system.

Table I shows the faceplate highlight illumination in foot-candles for several image orthicons and vidicons and gives the nearest equivalent ASA exposure index for various operating conditions of each. It is clear that a fairly significant range is possible with each of the tubes.

This is especially true of the vidicon. It can have a number of different ASA exposure index values as shown in Table I. This freedom to operate the vidicon over this wide range imposes the traditional condition of freedom: the necessity for making a choice. In the vidicon, high values of exposure index are achieved at the price of increased lag (a decrease in its ability to capture motion) and increasing nonuniformity of background. All the vidicons have the same intrinsic sensitivity. However, the 6198-A, 6326-A and 7038, which are newer types, have a more uniform photoconductor. They can be operated at higher dark currents, therefore, and provide a higher effective sensitivity.

ASA Rating in Nonstandard Scanning Systems

For image orthicons, these exposure ratings are also valid when the tube is used in scanning systems that operate on other than broadcast standards. The shutter speed used with the meter in each case must be the field rate of the system, unless the system employs a very low number of scanning lines so that there is little beam overlap. In this case, the frame rate should be used as the exposure time.

Vidicons, however, have a nonlinear characteristic, and these ratings are valid only within narrow limits. Insufficient experimental work has been done along these lines to verify any performance factors that might be calculated.

Rate of Response of TV Cameras

As has been said, the ability of a camera tube to capture motion is quite a different characteristic than the sensitivity of the tube, which is a measure of the quantity of light required to expose the tube.

The ability of a camera tube to capture or arrest motion is determined primarily by the scanning-system field rate but also is influenced by such factors as the relative exposure, storage capacitance and scanning-beam resistance, photoconductor response time, and signal-output levels of the tube. High storage capacitance, excessive beam resistance and underexposure are factors that produce an effective field time which is longer than the actual field scanning time. Overexposure of an image orthicon can make the effective field time shorter than the actual field scanning time.

This characteristic of a camera tube cannot readily be equated to film or film-camera terminology, as can be seen when Figs. 4 and 5 are compared.

Table I. ASA Exposure Indexes for Various Operating Conditions of Camera Tubes.

Image orthicon	Operating conditions (highlights)	Faceplate highlight illumination required, foot-candles	Nearest equivalent ASA exposure index
5820	at knee..........	0.01	16,000
	1 stop over knee	0.02	8,000
	2 stops over knee	0.04	4,000
6474	at knee.........	0.02	8,000
	1 stop over knee	0.04	4,000

Vidicon	Operating conditions, μa: Dark current	Operating conditions, μa: Signal	Faceplate highlight illumination required, foot-candles	Nearest equivalent ASA exposure index
6198 and 6326	0.02	0.3	10	16
	0.02	0.2	5	32
	0.004*	0.3*	100	1.6
6198-A and 6326-A	0.02	0.3	10	16
	0.02	0.2	5	32
	0.1	0.3	3	64
	0.1	0.2	1.5	125
7038	0.02	0.3	10	16
	0.02	0.2	5	32
	0.2	0.3	2	80
	0.2	0.2	1	160
	0.004*	0.3	100	1.6

* In bright outdoor or film-pickup service.

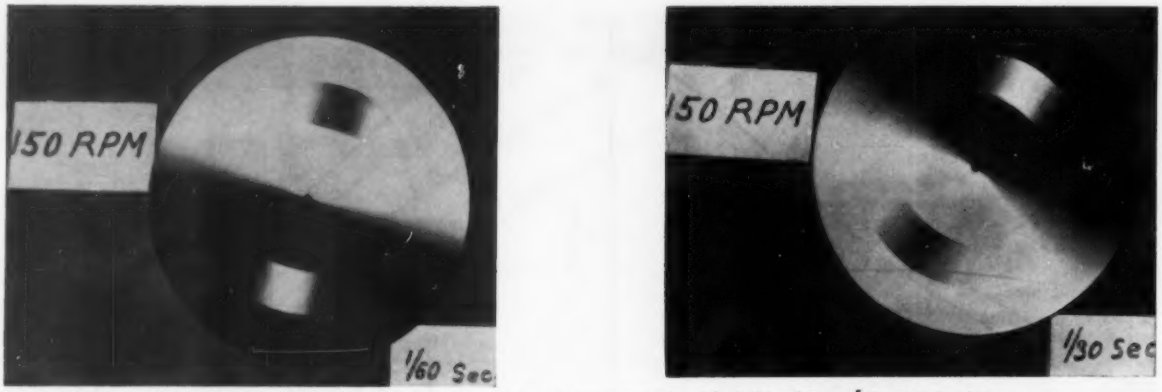

Fig. 4. Photographic exposure of rotating test pattern taken at shutter speeds of (a, left) 1/60 sec, (b, right) 1/30 sec.

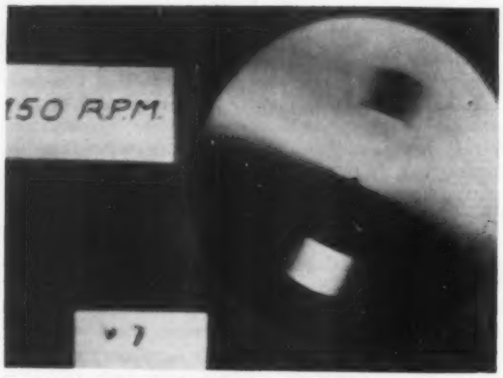

Fig. 5. Single field of vidicon picture from tube operating at low dark current (0.004 μa) and 0.3 μa signal output.

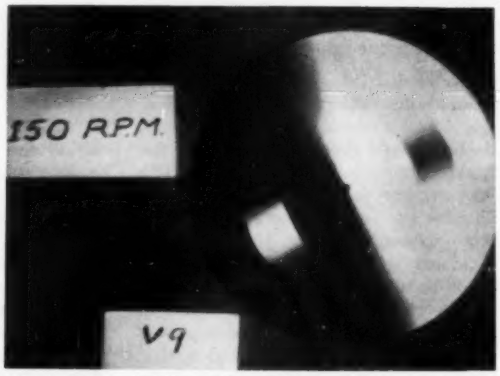

Fig. 6. Single field of vidicon picture from tube operating at high dark current (0.2 μa) on a 0.3 μa peak signal current.

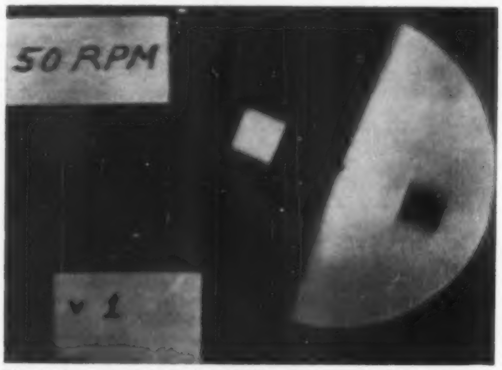

Fig. 7. Same as Fig. 5, but with pattern rotating at lower speed.

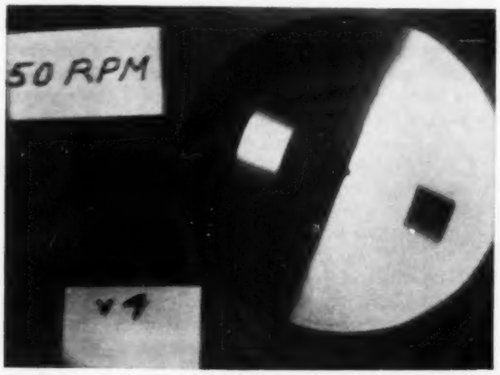

Fig. 8. Same as Fig. 6, but with pattern rotating at a lower speed.

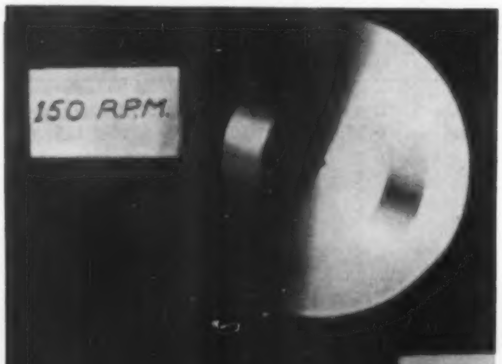

Fig. 9. Single field of picture from RCA-6474 image orthicon operating with highlights at the knee (as in color camera operation).

Figure 4 illustrates the type of smear that a moving image produces on a film. The shutter opens and closes abruptly, and the total image focused on each spot of the film while the shutter is open is recorded on the film. Figure 5 shows that the camera tube, on the other hand, remembers information from the preceding frame or exposure.

The image produced by a TV camera can be separated into two components: (1) the image generated by the charge-storage mechanism during the field time and (2) the image remembered from preceding frames. The first com-

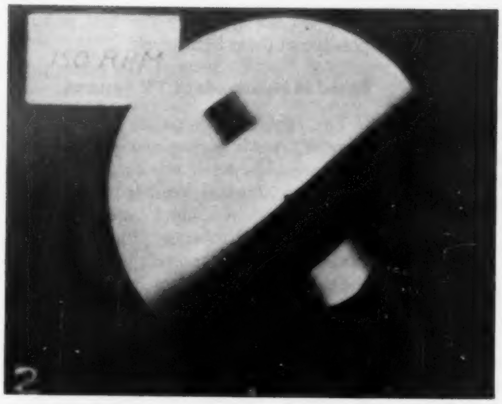

Fig. 10. Single field of picture from RCA-5820 image orthicon exposed with highlights one lens stop over knee.

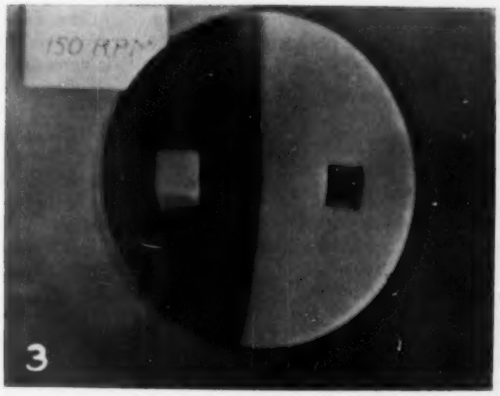

Fig. 11. Single field of picture from RCA-5820 image orthicon exposed two stops over knee, showing low-contrast trailing image on this field as a result of partial beam overlap into this field during the previous field scan.

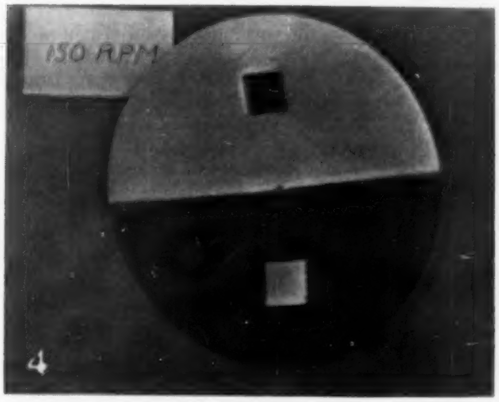

Fig. 12. Single field of picture from RCA-5820 image orthicon operating four stops over knee (note stroboscopic type of action-stopping).

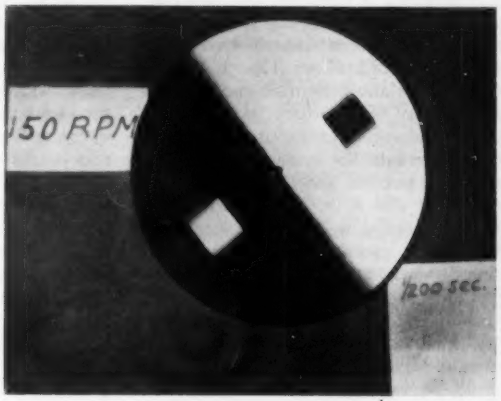

Fig. 13. Photographic exposure of test pattern taken at shutter speed of 1/200 sec.

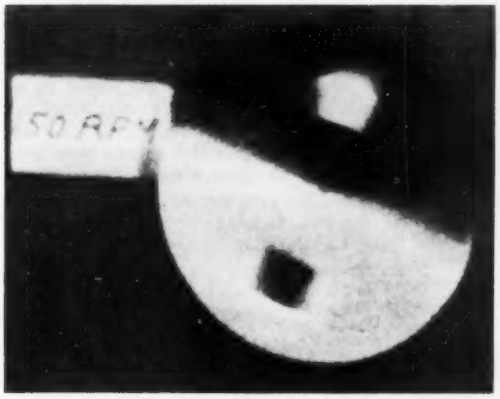

Fig. 14. Single field of picture from RCA-6849 image orthicon operating with photocathode highlight illumination of 1×10^{-3} foot-candles.

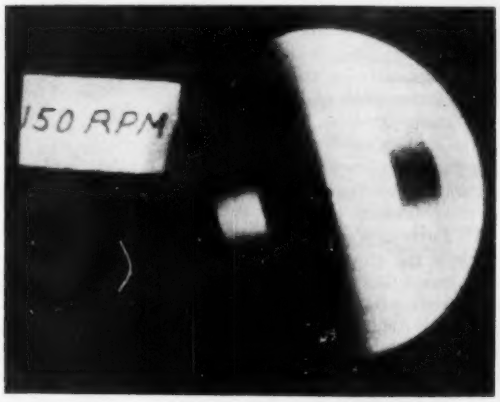

Fig. 15. Single field of picture from RCA-5820 image orthicon operating with photocathode highlight illumination of 1×10^{-3} foot-candles.

ponent is similar to a photograph obtained from a film camera operating with a shutter speed equal to the TV field rate. The second or remembered component is the low-contrast smear that extends over several of the positions that the image has covered in the past few frame intervals.

From the esthetic standpoint, the camera tube's ability to capture motion may appear to be quite poor because many fields may go by before every vestige of the "remembered" picture disappears (as shown by Fig. 5). From the standpoint of recording or detecting information, the TV camera has an ability to capture motion that corresponds favorably with a film camera operating at a shutter speed equal to the TV field scanning rate.

Figures 6 through 12, and 14 and 15 illustrate the motion-capturing ability of the various camera tubes and show the changes in this characteristic that

can take place under different operating conditions. These photographs show a single field of a TV image on the face of a special 10-in. kinescope. The P11 screen of this kinescope has a reasonably short decay time which limits "carry-over" of images from the previous field.

Figures 5 and 6 represent the performance of a vidicon operated at the extremes of its sensitivity range. Figure 5 represents the tube operating with approximately 100 foot-candles on the photosurface, and Fig. 6 represents operation with about two foot-candles of illumination on the photosurface. The equivalent exposure indexes of these examples are 1.6 and 80, respectively. There is little difference between the amount of smear on the boundaries of the high-contrast areas in the two images. A comparison of these two photographs and the photograph of the same object taken with a film camera having a shutter speed of 1/60 sec (Fig. 4b) shows that there is also little difference in the intelligibility of the three images. The long tail of the remembered component drags over into the second half of this particular pattern, and the photographs in Figs. 7 and 8 were taken with the pattern rotating at a slower speed to show more clearly the improvement gained when memory is reduced by operation of the vidicon at higher light levels.

The image orthicon is normally thought of as a rapid camera tube. As would be expected, when the tube is operated "under the knee" (no electron redistribution to reduce the effective charge-storage time on the target) the ability to capture motion cannot be much greater than that of the vidicon, whose motion-capturing ability is determined primarily by the TV field rate. Figure 9 shows the characteristics of the 6474 image orthicon, which has a high charge-storage time, operated in a color camera with practically no secondary electron redistribution taking place in the image section.

An interesting feature of this photograph is the second rather sharply defined image following the major image. The scanning beam of the image orthicon is sharper (with respect to the scanned raster size) than that of the vidicon. Therefore, it does not completely overlap onto the interlaced field and the frame is not completely scanned off; a part of the stored image remains on the second field until it is scanned off in its proper turn. In general, the image orthicon does not exhibit as much of the long tail of memory that is associated with the photoconductor and higher storage capacitance of the vidicon. It presents a picture that appears to be somewhat faster than the vidicon, at least when compared to a vidicon operating at maximum sensitivity.

The 5820 image orthicon, which is widely used in black-and-white television, is normally operated with the highlights considerably above the knee of its characteristic. The redistribution of electrons in the image section shortens the effective storage time, and results in an action-stopping ability that can appear to be better than that of a film camera having a shutter speed of 1/60 sec. Figures 10, 11 and 12 show the improvement in the motion-arresting ability of the image orthicon with increasing exposure. Figure 12, which represents operation four stops above the knee, shows a definite stroboscopic effect, as if the tube was exposed for only a part of the frame time. The sharpness of the leading and trailing edges of the moving object are equivalent to that obtained with a film camera shutter speed of 1/200 sec, as shown on Fig. 13. This photograph is similar to that produced by a motion-picture film camera at normal frame rates and a fast shutter speed. The moving images appear to the eye in a sequence progressing across the screen rather than as the smeared image that results with normal shutter speeds on a film camera, or that is associated with full-storage operation of a TV camera tube. Photographically, the image in Fig. 12 is not very precise and has spurious shadows around the highlighted areas. Unfortunately, these spurious shadows are very often typical of broadcast television practice, particularly in outdoor shots where more than adequate light is available. However, this type of operation can be an advantage in certain instances, such as a ball game when the camera picks the white baseball out of its surroundings, arrests its motion, and displays it as a series of images progressing across the picture.

Special Image Orthicons

The RCA-6849 image orthicon was designed to operate at very low light levels and yet have a reasonable speed. This tube has an extremely low capacitance target that overcomes the long tail due to the remembered image which develops when a standard image orthicon is operated at very low light levels. Photographs of its performance at low light levels and that of a 5820 image orthicon at the same levels are shown in Figs. 14 and 15, respectively. As can be seen, the smear of the moving image on the 6849 is determined almost entirely by the TV field rate. The 5820 exhibits a very long tail that limits its ability to capture motion at these light levels. An equivalent exposure index value of 160,000 is used to determine the illumination of the tubes for these illustrations. However, it is unfair to speak of an exposure index in this case because an exposure index implies that the best picture possible will result when the particular device is so exposed. These tubes do not generate the best picture possible at these light levels.

Speed in Nonstandard TV Systems

The rapidity of response of most TV camera tubes is determined primarily by the scanning-system standards. For the most part, this statement is true for any scanning system using image orthicons. One method of improving the ability of a camera tube to capture motion can be the use of a faster field or frame-scanning rate. In another technique, the scanning beam is partially defocused to discharge the interlaced field more completely during each field interval. This technique is usually essential to improve color purity in field-sequential TV color systems.

Another method of improving this characteristic of the image orthicon is to pulse the image section of the tube in such a way as to charge up the target for only a brief interval. A short charge time is best accomplished by pulsing the photocathode positively to zero voltage during the scanning interval, and to normal photocathode voltage during the retrace interval. Thus, the target charges during the retrace interval. Very short "on" pulses during the scanning interval usually produce a line across the picture during the transitions of the pulse. The utilization of a slow transition on this pulse eliminates this line from the picture, but the defocused image during the slow transition spoils the picture resolution. Pulsing the image section of the tube is a very useful means of increasing the effective speed of a TV scanning system. The light levels on the tube must be increased to compensate for the shorter target charging time and the resultant loss in the effective sensitivity of the system.

The vidicon cannot be pulsed in a similar manner, but a shutter synchronized to the field scanning rate achieves the same result. This shutter does not have to be opened during the retrace time, but can operate any time during the field scanning interval so long as it is synchronized to the same portion of each field interval.

APPENDIX

The critical item in the relationship between the light requirements of a film and a TV camera tube is the determination of the actual highlight exposures of a film in relationship to the value E, the term for light in the ASA exposure index.

The most straightforward way of determining this value of light is to start from the American Standards Association calibration formula for reflected light exposure meters (see ASA PH2.12-1957).

This type of meter is calibrated in accordance with the following formula.

$$T = \frac{KA^2}{BS} \quad \text{(A1)}$$

From ASA PH2.5-1954,

$$S = \frac{1}{4E_1} \quad \text{(A2)}$$

Then, from Eqs. (A1) and (A2),

$$T = \frac{KA^2}{B} 4E \quad \text{(A3)}$$

In these equations,

T = exposure time, sec,
A = relative aperture or f number,
B = brightness of uniform brightness surface, candles/sq ft,
S = film exposure index,
E_1 = exposure, meter-candle-seconds (see ASA PH2.5-1954), and
K = a constant which can range from 1 to 1.35 (to allow some latitude for different methods of use of the meter as prescribed by the manufacturer).

This formula is not necessarily a rational equation since a dimensional analysis shows that time T is equal to $\sec \cdot f^2/m^2$! However, by definition it is used to determine the time of exposure and relative aperture of a lens when the meter is illuminated from a source of uniform light having a known brightness.

The ratio of the exposure E_H to the value E_1 (which results when a film is exposed using a meter calibrated according to this standard) can be determined in the following manner. If the meter is directed toward a typical indoor scene, the average brightness of the scene will be about one-fifth that of the highlight brightness B_H.

$$B_A = 1/5\ B_H \quad \text{(A4)}$$

Since the exposure meter is calibrated in terms of *average* brightness of a uniform source completely filling its field of view, the time of exposure in terms of highlight brightness and ASA exposure index S is, from Eq. (A3):

$$T = \frac{KA^2}{B_H} 20\ E_1 \quad \text{(A5)}$$

The highlight exposure of the film E_H resulting from the data obtained from this meter reading is

$$E_H = T \times I_{\text{film}} \quad \text{(A6)}$$

where

T = time of exposure, sec, and
I_{film} = film highlight illumination, meter-candles.

The value of I_{film} is determined in the following manner from the familiar lens equation:

$$I_{\text{film}} = \frac{B_H \pi t}{4A^2(M+1)^2} \quad \text{(A7)}$$

where

t = lens transmission, and
M = magnification.

(M approaches 0 in all but close-up shots and can be dropped.)

Since B_H of the ASA meter calibration formula is in units of candles per square feet, it is necessary to convert this to candles per square meter by multiplying B_H by 10.76 so that the illumination values will be in meter-candles.

$$I_{\text{film}} = \frac{B_H \pi t}{4A^2} 10.76 \quad \text{(A8)}$$

Substituting from Eqs. (A5) and (A8) in Eq. (A6) gives

$$E_H = \left(\frac{KA^2}{B_H} 20\ E\right)\left(\frac{B_H \pi t}{4\ A^2} 10.76\right) \quad \text{(A9)}$$

By assuming the lens transmission to be a nominal value of 0.75, we obtain from Eq. (A9),

$$E_H = K\ (5E)(10.76)(3.1416)(0.75) = 126\ KE \quad \text{(A10)}$$

If K is given the conservative value of 1.0, $E_H = 126E$, showing that the highlights of a film exposed using a meter calibrated in terms of ASA exposure index will be 126 times the value E in the ASA film exposure index formula given in Eq. (A2).

Acknowledgments

The valuable assistance provided by B. H. Vine in formulating the presentation of the section on sensitivity, and by J. B. Bucher, L. D. Miller and G. A. Robinson in the preparation of photographs illustrating the motion-capturing ability of the camera tubes is gratefully acknowledged.

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Discussion

Don Hart (Smith, Kline and French): Would you care to comment on speeds and sensitivity regarding other wavelengths of light, such as ultraviolet and infrared?

Mr. Neuhauser: I don't have those figures here so I can only give you relative values. In the ultraviolet region the speed of our ultraviolet-sensitive camera tube, not the ones I described here, is just about equal to the vidicon operated at what I call its medium sensitivity level, an index of about 10. You cannot "drive" that tube as hard as you can the other tubes to get the increased sensitivity. None of the presently available vidicon tubes have appreciable sensitivity in the infrared. If there is any sensitivity in any of these vidicons, it is only a slight sensitivity extending out into the 8, 9 and 10 micron range. The effective sensitivity out there is down by a factor of 100 compared to the visible light sensitivity.

Mr. Hart: Didn't the old 5820 have considerable infrared response?

Mr. Neuhauser: The old 2-P23 which is a predecessor to the 5820 did have some infrared response. It went out, I think, almost to 12,000 angstroms although they were processed deliberately to suppress that infrared peak and bring up the visible peak; that was the best photosurface available at that time. They are not necessarily very stable in operation out in the infrared region, and were very susceptible to slumping of sensitivity in the infrared region.

Frank Gillette (General Precision Laboratory, Inc.): You speak of using a shutter with a vidicon. Do I understand that the only requirement is that it be synchronous?

Mr. Neuhauser: Yes, this is quite similar to film camera operation. We used to recommend that the time of application be equal to at least 30% of the field to avoid what is called an application bar. This still holds true, particularly if the shutter is not exactly phased with the field scanning rate. I think if it's well phased you can go down to less than 10%, as long as it doesn't change phase from frame to frame. If it's applied in such a phase so that it occurs during the retrace interval it can be much shorter since any pulse caused by the short high-intensity light pulse won't interfere with the major portion of the picture.

Frederick Lewis (Telecircuit, Inc.): I believe you gave the figure, 17,000, as an ASA speed for the 5820. If you set your TV lens at 5–6, which is about normal for a TV studio, that would work out mathematically to a scene level of 6 ft-c. Is that your recommended level?

Mr. Neuhauser: That is the light level required to hit the knee of the transfer characteristic. For normal black-and-white studio operation, the lens is opened between 1 and 2 stops above the knee. This would require four times the amount you computed. These values I gave are typical of the normal image orthicon when it is operated when new. The sensitivity does decrease somewhat during its life but I am also of the firm opinion that most black-and-white studios are grossly over-lit — they try to get their contrast by running the exposure way over knee resulting in a lot of spurious secondary electron redistribution, instead of putting proper contrast in the lighting.

Mr. Lewis: What do you recommend as normal for a 5820 — the lighting level?

Mr. Neuhauser: 50 to 75 foot-candles with a lens opening of about $f/8$ is adequate light in my estimation. I think that compares to an exposure which is equivalent to an ASA exposure index of about 4000.

Karl-Heinz Lohse (formerly, U. S. Steel Corp.; now, Aeronautronic Systems, Inc., subsidiary of Ford Motor Co.): Do the picture tubes show similar phenomena such as reciprocity-law failure. For instance, if you determine your speed by using a very fast light source, or an extremely low light level of illumination instead of typical studio lighting, do they follow the reciprocity law?

Mr. Neuhauser: I assume that the point is raised because the film sometimes departs from reciprocity when you get down to extremely low light levels and long exposure times compared to short exposure times and high light levels. As far as I know the image orthicon does not have any reciprocity failure. We have not done much work on the vidicon in this respect and, at least within limits of 10 to 1, reciprocity does hold true. In other words, it holds true down to a 10% duty cycle. I don't have any data on operation with shorter duty cycles but I see no reason why reciprocity shouldn't hold true to even shorter duty cycles.

Dr. Gillette: We have operated these orthicons with considerably shorter duty cycles than that and found reasonably good behavior.

Mr. Neuhauser: I would assume that you would.

On the Detective Quantum Efficiency of Television Camera Tubes

By R. CLARK JONES

The detective quantum efficiency of two RCA image orthicons (5820 and 6849) and one RCA vidicon (6326) is computed from unpublished signal, noise and resolution data generously supplied by the manufacturer. The concept of detective quantum efficiency used here is identical with the concept of quantum efficiency introduced by Rose in 1946, and is defined as the square of the ratio of the measured signal-to-noise ratio to the maximum possible signal-to-noise ratio under the same external conditions, where the maximum possible signal-to-noise ratio is set by the statistical fluctuations in the number of the photons in the background. The detective quantum efficiency Q is presented as a function of the wavelength of the photocathode radiation, of the irradiation of the cathode and of the line-number of the target. The maximum value of Q with respect to variation of the wavelength, irradiation and line-number is 2.65% for the 5820 and 4.35% for the 6849 image orthicons and only 0.084% for the 6326 vidicon.

THE DETECTIVE quantum efficiency of a number of RCA television camera tubes is determined in this paper. The detective quantum efficiency, defined below, is one of the best measures of the performance of a camera tube.

There are two methods of evaluating any kind of radiation detector. The first is to state the smallest amount of power (or power per unit area) that may be detected by the detector under consideration, under the condition that, aside from the radiation to be detected, the only radiation present is the room-temperature blackbody radiation field. This method is a good one for such detectors as bolometers, thermocouples and photoconductive cells. The detecting performance of a large number of different kinds of detectors (not including camera tubes) has been reviewed by the writer[1] from this point of view.

But for some detectors this is not a useful approach because under practical conditions of use the level of the noise may be much greater than when the tube is in complete darkness. For example, with a multiplier phototube, the mean square noise current is a constant plus a term proportional to the intensity of the light incident on the sensitive surface.

The second method therefore considers that the limiting noise is not a fixed parameter of the detector, but is a noise that depends on the level of the ambient illumination. This approach is appropriate for some camera tubes, photographic negatives, human vision and photoemissive tubes. Adopting this latter approach, we shall see that the natural measure of the efficiency of a detector is the detective quantum efficiency, to be defined in the next section.

The concept of detective quantum efficiency was introduced in 1946 by Rose[2] and was used by him to describe the performance of human vision, photographic negatives and camera tubes.[3,4] The detective quantum efficiency of human vision was more recently studied by the present writer.[5,10]

The concept of detective quantum efficiency is to be sharply distinguished from the more commonly used type of quantum efficiency, which the writer calls *responsive* quantum efficiency.

The Two Kinds of Quantum Efficiency

A responsive quantum efficiency is always the ratio of the numbers of two kinds of countable events. For example, the responsive quantum efficiency of a photoemissive tube is defined as the ratio of the number of electrons that reach the anode to the number of photons that are incident on the phototube.

This type of quantum efficiency may be greater than unity and in fact is usually far greater than unity in multiplier phototubes.

The detective quantum efficiency Q of an actual detector is defined as the square of the ratio of (1) the signal-to-noise ratio of the actual detector to (2) the maximum possible signal-to-noise ratio, for a given signal in the presence of a given steady ambient radiation. As implied by this definition, the key concept is "the maximum possible signal-to-noise ratio, for a given signal in the presence of a given steady ambient radiation." We proceed to examine this concept.

In a given (integration) period T, the average number of photons supplied to the responsive area of the detector by the steady ambient radiation is denoted by $\bar{M}_a$. In successive integration periods each of length T, the number of photons M_a in any given period will not be exactly equal to $\bar{M}_a$ because the arrival of each individual photon is a random event. In the language of Fry,[6] the photons arrive both individually and collectively at random. It then follows, as shown by Fry, that the distribution of the number of photons in successive periods is a Poisson distribution. From this it in turn follows that the root-mean-square fluctuation N of the number of photons is given by

$$N \equiv [(M_a - \bar{M}_a)^2]_{avg}^{1/2} = \bar{M}_a^{1/2} \quad (1)$$

We use $\bar{M}_s$ to denote the average number of signal photons that reach the responsive area in the period T:

$$S \equiv \bar{M}_s \quad (2)$$

The signal-to-noise ratio that is intrinsic in the radiation that falls on the detector is the ratio of S to N:

$$S/N = \bar{M}_s/\bar{M}_a^{1/2} \quad (3)$$

This is the signal-to-noise ratio in the radiation that falls on the detector, and it follows that no detector can have a higher signal-to-noise ratio in its electrical output. Actual detectors will always have a smaller signal-to-noise ratio.

We assume that $\bar{M}_s$ is small compared with $\bar{M}_a$. This condition assures that the noise is not appreciably changed by the presence of the signal.

A (nonexistent) ideal detector, which would have in its electrical output a signal-to-noise ratio equal to that given by Eq. (3), would be the combination of a noiseless amplifier and a photoemissive tube (no internal amplification) having a responsive quantum efficiency of unity and zero dark-current.

Now let $(S/N)_m$ be the measured signal-to-noise ratio of an actual detector. Then if $\bar{M}_a$ and $\bar{M}_s$ are the photon numbers that prevailed when this signal-to-noise ratio was measured, the definition given above for the detective quantum efficiency Q of the actual detector yields

$$Q \equiv \left(\frac{S}{N}\right)_m^2 \frac{\bar{M}_a}{\bar{M}_s^2} \quad (4)$$

In specific application to camera tubes, it will be supposed that the responsive area of the tube is uniformly illuminated by radiation; this uniform irradiation is called the ambient radiation. It is further supposed that there is also additional radiation, the signal, which uniformly irradiates some part of the responsive area.

The detective quantum efficiency depends on the radiation wavelength and on the amount of the ambient

A contribution by Dr. R. Clark Jones, Research Laboratory, Polaroid Corporation, Cambridge 39, Mass., first received on August 12, 1958, and in its present form on February 27, 1959.

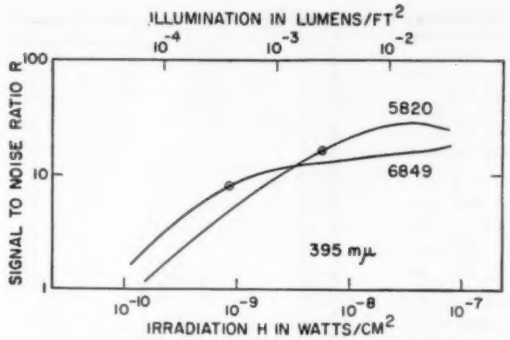

Fig. 1. The signal-to-noise ratio of two kinds of image orthicons (5820 and 6849) plotted vs. the cathode illumination in lumens (of "white" fluorescent light) per square foot. An alternative scale indicates the cathode irradiation in watts (of 3950 A radiation) per square centimeter. The signal-to-noise ratio is the ratio of the peak signal voltage (for a black-to-white transition) to the rms noise voltage in a bandwidth slightly greater than 4.5 mc.

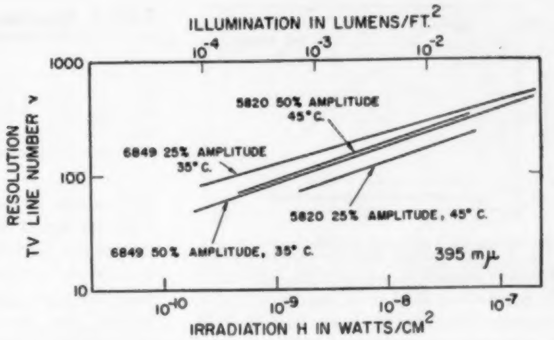

Fig. 2. The television line-number of image orthicons (5820 and 6849) for two different amplitude responses plotted vs. the cathode illumination and the cathode irradiation. The curves labeled "25% amplitude" indicate the line-number at which the electrical response is one-fourth of the response for any very small line-number, and similarly for the other two curves.

radiation. It depends also on the area covered by the signal. (There is no dependence if the signal area is sufficiently large.)

Experimental Data

In this paper the detective quantum efficiency Q is calculated for two RCA image orthicons and one RCA vidicon as a function of photocathode illumination, size of signal area and the radiation wavelength. The two image orthicons are the RCA 5820 and the RCA 6849, the latter being the wide-spaced version of the former. The vidicon is the RCA 6326. The vidicon is treated separately later in the paper.

The writer is much indebted to F. David Marschka, George A. Morton and Benjamin H. Vine, of the Radio Corporation of America, for supplying unpublished information on the performance of these image orthicons. Most of this information is shown in Figs. 1 and 2.

Figure 1 shows the electrical signal-to-noise ratio R of the two camera tubes as a function of the photocathode irradiation in watts per square centimeter of 3950 A monochromatic radiation. The signal is the peak-to-peak output voltage when the orthicon sees a pattern that has high contrast between areas of large angular subtense. (Such a pattern will be called briefly a large-area black-to-white transition.) The noise is the rms electrical noise voltage in a bandwidth that is slightly greater than 4.5 mc/sec. The beam current was separately adjusted for each of the experimental points on which the curves in Fig. 1 are based. The original data supplied by RCA involved an abscissa equal to the photocathode illumination in lumens per square foot of radiation from a bank of Sylvania "white" fluorescent lamps. Keith Butler, of Sylvania Electric Products, has kindly supplied the relative radiant output of these lamps per unit wavelength interval. By combining this information with the relative spectral responsivity of the image orthicons as given by the *RCA HB-3 Tube Handbook*,[7] I calculate that 480 lm are equivalent to one watt of 3950 A radiation. (This ratio is slightly greater than the ratio found below of 450 lm of 2870 K tungsten radiation per watt of 3950 A radiation.)

Figure 2 shows the way that the resolution of the two camera tubes depends on the photocathode irradiation. The four curves, two for each tube, show the line-numbers at which the response has decreased to 0.5 and 0.25 of the large-area response. These data also were originally supplied with the abscissa given in lumens per square foot of fluorescent radiation.

The *RCA HB-3 Tube Handbook* indicates that the responsivity of the photocathode in amperes per watt peaks at 4250 A with the value 0.0173 amp/w. This corresponds to a responsive quantum efficiency of 5.04%. Since the energy of a photon is inversely proportional to the wavelength, the responsive quantum efficiency in electrons per photon has its maximum value at the wavelength where the responsivity divided by the wavelength is a maximum. This maximum occurs at 3950 A, where the responsivity is 0.0166 amp/w; this corresponds to a responsive quantum efficiency of 5.21%.

RCA has supplied the additional information that the response-versus-wavelength data just referred to correspond to a responsivity of 36.6 μa/lm of 2870 K radiation, from which we conclude that 453 lm of 2870 K radiation is equivalent to one watt of 3950 A radiation.

RCA has supplied the additional information that the image orthicons now being manufactured have a higher responsivity than is indicated above, and that the particular tubes used to obtain the data in Fig. 1 had a responsivity of about 60 μa/lm and about 0.027 amp/w. Thus for these newer tubes the responsive quantum efficiency is about 8.1%, and the ratio of responsivities is 450 lm/w. Thus the abscissas in Figs. 1 and 2 may be converted to photocathode current in amperes per square centimeter by multiplying the abscissa by 0.027 amp/w. Alternatively, the abscissas may be converted to lumens per square centimeter by multiplying the abscissa by 480 or 450 lm/w for the two kinds of light mentioned above.

The photocathode is 0.96 by 1.28 in., and thus has an area of 1.23 sq in. = 7.93 sq cm.

Derivation of a Working Equation for Q

The average number of photons that are incident on a surface of area A with the irradiation H during the period T is given by

$$\bar{M}_a = HATn \tag{5}$$

where n is the number of photons in a watt-second of the radiation, and H is the irradiation in watts per square centimeter. The factor A is measured in square centimeters, and T in seconds.

If the contrast of the signal to be detected is ϵ, the corresponding number of signal photons is given by

$$\bar{M}_s = \epsilon \bar{M}_a \tag{6}$$

We note that the signal-to-noise ratio R plotted in Fig. 1 is the ratio for a black-to-white transition; the contrast of this signal is thus unity. For a transition of contrast ϵ, the signal-to-noise ratio would be ϵR.

If the image orthicon itself had no resolution limitations, then we could

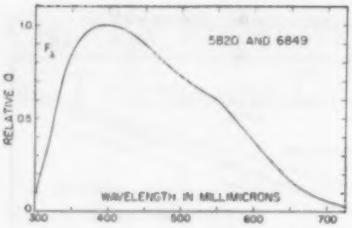

Fig. 3. The relative detective quantum efficiency plotted vs. wavelength. The curve is normalized so that its maximum value is unity. The curve applies to both kinds of image orthicons (5820 and 6849).

say that the electrical signal-to-noise ratio ϵR in a 4.5-mc bandwidth would be equal to the signal-to-noise ratio $(S/N)_m$ for a signal spot of size equal to the smallest area that can be resolved of such a bandwidth. If A_c is the photocathode area, this smallest area A_{min} is given by

$$A_{min} = A_c/(2BT) \qquad (7)$$

where B is the bandwidth of 4.5 mc, and T is the period already introduced which must now be taken equal to the frame time $\frac{1}{30}$ sec of the normal mode of operation of the image orthicon.

To derive the signal-to-noise ratio $(S/N)_m$ for larger signal areas, we note that the frequency bandwidth required to transmit a signal spot of area A is inversely proportional to A. The required bandwidth is 4.5 mc for the area A_{min}, and is only 15 cps for a signal that uniformly covers the photocathode. Since, furthermore, the noise has a flat spectrum, the signal-to-noise ratio for a signal spot of area A is given by

$$(S/N)_m = (A/A_{min})^{1/2}\epsilon R \qquad (8)$$

We now substitute the last four relations in Eq. (4), with the result:

$$Q = \frac{2B}{A_c n}\frac{R^2}{H} \qquad (9)$$

We note that in the process of substitution, the quantities A, T and ϵ cancel out. Equation (9) is the general expression for the detective quantum efficiency of an image orthicon.

The numerical values of the bandwidth B, of the cathode area A_c and of the ratio n at 3950 A are

$$\begin{aligned} B &= 4.5 \times 10^6 \text{ cps} \\ A_c &= 7.93 \text{ sq cm} \\ n &= 1.989 \times 10^{18} \text{ photons/w-sec} \end{aligned} \qquad (10)$$

The expression (9) thus reduces to

$$Q = 5.71 \times 10^{-13} R^2/H \qquad (11)$$

where H must be in watts per square centimeter, and R is dimensionless.

Equation (11) is the final "working" expression for the detective quantum efficiency Q in terms of the measured quantities R and H. In this expression, Q is a fraction (not in per cent), and H is in watts per square centimeter. It is particularly to be noted that the area A of the signal does not appear in this expression. Actually, of course, the area A fails to appear because of our assumption that the performance is not limited by the resolution capability; for sufficiently small areas the detective quantum efficiency will decrease, and this decrease is examined in the next section.

Table I. Data for the Image Orthicons.

	5820	6849
R	16.2	8.1
H, w/sq cm	5.65×10^{-9}	8.63×10^{-10}
Q_{max}, %	2.65	4.35

Results for Image Orthicons

The fact indicated by Eq. (11) that the detective quantum efficiency Q varies as R^2/H means that curves of constant Q in Fig. 1 would be straight lines with a positive slope of one-half. The point where each of the two curves has a slope of one-half is indicated by the open circles in Fig. 1.

The values of R and H at these two points are indicated in Table I. The last row of Table I shows the value of Q computed for these two points by Eq. (11), in per cent.

These values of Q are of course the maximum value of the detection quantum efficiency with respect to radiation wavelength, image size and photocathode irradiation. The value of Q under other conditions is related to its maximum value by

$$Q = Q_{max}F_\lambda F_\nu F_H \qquad (12)$$

where the three F's are factors with a maximum value of unity, that depend respectively on the radiation wavelength, line-number and illumination.

The factor F_λ, which takes into account the variation of Q with the wavelength λ, is easily shown to vary with wavelength in proportion to the *responsive* quantum efficiency of the photocathode, which in turn is proportional to the responsivity (in amperes per watt) divided by the wavelength, as indicated above. Suppose for example, that we consider a wavelength where the *responsive* quantum efficiency is just half its value at 3950 A. This means that both the signal and ambient photon fluxes $\bar{M}_s$ and $\bar{M}_a$ must be doubled in order to produce the same photocurrents as before. It then follows directly from Eq. (4) that Q is reduced to half its previous value. The experimental data on the responsivity used to construct Fig. 3 were taken from the *HB-3 Tube Handbook*.[7]

To assure that F_λ represents the variation of the detective quantum efficiency with wavelength, the ambient flux must vary inversely as the function F_λ in order that the photocathode current be held at its optimum value. With reference to Fig. 3, one can see that this is equivalent to the statement that the photocathode current be held at 0.00150 μa for the 5820 image orthicon and at 0.000237 μa for the 6849.

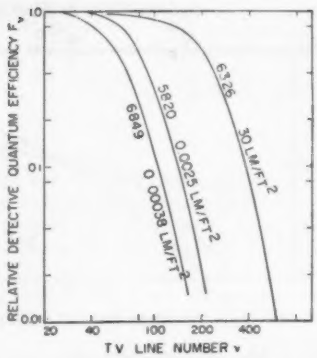

Fig. 4. The relative detective quantum efficiency plotted vs. the television line-number. The ordinate is equal to the square of the amplitude line-number response. The two image-orthicon curves (5820 and 6849) apply only when the cathode illumination is such as to maximize the detective quantum efficiency; see Table I. With the data in this figure and the data in Figs. 2 and 3, and in Tables I and II, one may compute the detective quantum efficiency of either image orthicon for any combination of radiation wavelength, line-number and cathode illumination.

The detective quantum efficiency Q_{max} applies to a target so large as to be completely resolved. The detective quantum efficiency is smaller for targets that are not fully resolved. Schade[8] has shown how the response of an image system for a target of any size and shape may be calculated from the line-number response of the system by Fourier methods. For the sake of brevity, we omit this transformation, and simply show how the detective quantum efficiency depends on the line-number of a simple pattern that may be described adequately by a narrow range of line-numbers. The factor F_ν shown in Fig. 4 is proportional to the square of the line-number response. The shape of this curve depends on the irradiation level as shown by Fig. 2. The two image-orthicon curves in Fig. 4 are both for the irradiation level shown in Table I for which Q is a maximum for large-area targets.

The development of the full significance of the function F_ν would require the introduction of two-dimensional Fourier analysis, and would necessitate an extensive discussion out of proportion to its importance to this paper.

The function F_H is tabulated in Table II. The shapes of the functions with logarithmic coordinates are the same as the curves of Q versus H in Fig. 7. The

Table II. Values of F_H at 3950 A for the Image Orthicons.

H, watt/sq cm	F_H 5280	F_H 6849
1×10^{-10}	0.137	0.28
2	0.235	0.52
4	0.38	0.83
8	0.57	1.00
10	0.64	0.99
20	0.85	0.78
40	0.99	0.50
80	0.98	0.30
100	0.95	0.25
200	0.75	0.148
400	0.43	0.084
600	0.26	0.062

function F_H is equal to the ratio of R^2/H as given by the data in Fig. 1 to the maximum value of R^2/H. The functions shown in Table II are for radiation of the wavelength 3950 A. For other wavelengths, the curves of F_H versus H should be shifted to the right by a factor equal to the reciprocal of F_λ.

Detective Quantum Efficiency of the RCA 6326 Vidicon

As indicated in the early paragraphs of this paper, the detective quantum efficiency is best adapted to describing the performance of radiation detectors whose noise is due to the fluctuation in the arrival of the ambient photons at the sensitive surface. The vidicon is not a member of this class of detectors. The noise at the output of the amplifier associated with the vidicon is quite independent of the level of ambient illumination. Accordingly, if the vidicon were being compared with detectors in general, it would be more suitable to evaluate it by the methods of reference 1.

But in this paper we are not interested in comparing the vidicon with detectors in general. Rather, we wish to compare its performance with other camera tubes, the image orthicon in particular. Since the image orthicon is suitably evaluated by means of the detective quantum efficiency, we shall use this method also for the vidicon.

The signal-to-noise ratio of the vidicon camera tube is substantially degraded by the noise of the best available video amplifier. The noise level depends to some extent on the degree of frequency compensation used in the amplifier, which compensation corrects the horizontal response for the aperturing effect of the scanning beam, and for the shunt capacity of the tube. The electrical signal-to-noise ratio R shown in Fig. 5 and the F_ν function shown in Fig. 4 are for no compensation, and represent the situation in which the spectrum of the noise at the output of the amplifier is approximately flat. The curves in Figs. 4 and 5 are based on Figs. 8 and 10 of the RCA Bulletin describing the 6326 vidicon, and on information (kindly supplied by A. D. Cope and Benjamin H. Vine of RCA) to

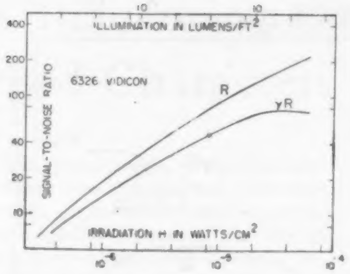

Fig. 5. The signal-to-noise ratio R of the 6326 vidicon for a black-to-white transition, and also γR, plotted against the cathode illumination and cathode irradiation. The illumination is in lumens per square root of 2870 K radiation, and the irradiation is in watts per square centimeter of 4350 A radiation.

the effect that the noise current referred to the output of the tube is about 1.5×10^{-9} amp in a 4.5-mc bandwidth. The curves in Fig. 5 are for a large-area black-to-white transition, and are for monochromatic light of wavelength 4350 A. From the data in Figs. 8 and 10 of the 6326 Bulletin, one finds that the tube's responsivity/wavelength ratio has a maximum at this wavelength, and that one watt of 4350 A radiation produces the same response as 520 lm of 2870 K tungsten radiation.

Unlike the response of the image orthicon, which is linear for illuminations below the "knee" of the characteristic curve, the response of the vidicon is nonlinear, with a "gamma" less than unity. Thus the signal-to-noise ratio from a large-area target of small contrast ϵ will not be ϵR, but will rather be $\epsilon\gamma R$, where γ is the gradient of the log current output vs. log irradiation curve.

A plot of γR vs. H is also shown in Fig. 5.

We shall base our calculation on the assumption that the integration time of the vidicon is $\frac{1}{30}$ sec. This assumption, which is very sound for image orthicons, is not exact for vidicons. These camera tubes have appreciable carry-over from one frame to the next, which is small at the recommended illumination of 30 lm/sq ft, but which becomes quite marked at much lower illuminations; this integration increases significantly the signal-to-noise ratio at lower illuminations, at the cost of blurring rapid motion. In the absence of detailed information about the amount of temporal integration as a function of illumination, we make the simple assumption that the integration time is $T = \frac{1}{30}$ sec.

Then we obtain the same expression as Eq. (11), except that the righthand side contains also the factor γ^2:

$$Q = \frac{2B}{A_c n} \frac{(\gamma R)^2}{H} \qquad (13)$$

In normal operation, the bandwidth B

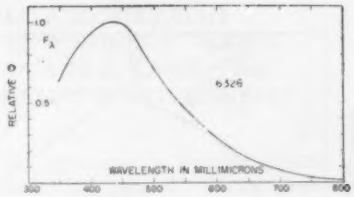

Fig. 6. The relative detective quantum efficiency of the 6326 vidicon plotted vs. the radiation wavelength. The curve is normalized.

Table III. Data for the 6326 Vidicon.

γR	47.5
H	8.28×10^{-6} w/sq cm
Q_{max}	0.084%

of the vidicon is the same as that of the image orthicon, and the sensitive area A has the dimensions 0.5 in. by 0.375 in. One thus has

$$\begin{aligned} B &= 4.5 \times 10^6 \text{ cps} \\ A_c &= 1.342 \text{ sq cm} \\ n &= 2.19 \times 10^{18} \text{ photons/w-sec} \end{aligned} \qquad (14)$$

where the value of n is that for 4350 A.

One now obtains

$$Q = 3.06 \times 10^{-12} \gamma^2 R^2/H \qquad (15)$$

as the "working" expression for the detective quantum efficiency in terms of the quantities H and γR. In this expression Q is a fraction and H must be in watts per square centimeter.

The detective quantum efficiency varies as $\gamma^2 R^2/H$. The point on the curve in Fig. 5 where this ratio has its maximum value is indicated by an open circle. The values of γR and H at this point, and the value of the detective quantum efficiency computed by Eq. (15), are shown in Table III, where Q_{max} is the maximum value of the detective quantum efficiency with respect to the radiation wavelength, size of the signal image and amount of ambient radiation. The factors F_λ, F_ν and F_H, defined as in the preceding section, are shown in Figs. 6, 4 and Table IV.

The function F_λ is proportional to the responsivity (plotted in Fig. 10 of the RCA Tube Bulletin for the 6326 vidicon) divided by the wavelength. The function

Table IV. Values of F_H at 4350 A for the 6326 Vidicon.

H watt/sq cm	F_H
0.4×10^{-6}	0.52
0.8	0.69
1	0.74
2	0.89
4	0.97
8	1.00
10	0.99
20	0.89
40	0.54
60	0.285

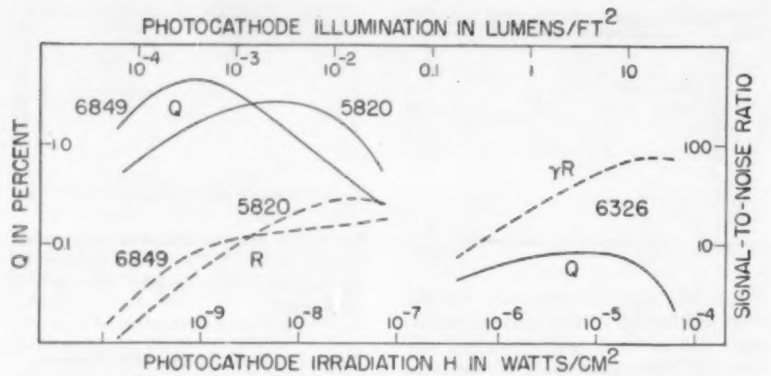

Fig. 7. A summary plot showing both the detective quantum efficiency Q **(solid curves) and the signal-to-noise ratio (dashed curves) of all three camera tubes (5820 and 6849 image orthicons and 6326 vidicon) plotted vs. the cathode illumination and the cathode irradiation.** The values of Q assume optimum choice of radiation wavelength and television line-number.

F_v is proportional to the square of the response versus line-number. The function F_H is equal to the ratio of γ^2R^2/H to its maximum value. Many of the comments made in the preceding section about the F-functions apply also to the F-functions of this section.

The fact that the limiting noise of the vidicon is amplifier noise has an important consequence. If an image orthicon had a detective quantum efficiency of only 0.084% (the value for the vidicon) under the best conditions, the responsive quantum efficiency of the photocathode would have to be increased by the factor 52 to equal the 4.35% detective quantum efficiency of the 6849 image orthicon. But since the noise of the vidicon is amplifier noise, the responsivity of the vidicon's photocathode would have to be increased only by the factor $7.2 = 52^{1/2}$ in order that the detective quantum efficiency rise to 4.35%, provided that the noise of the vidicon proper continues to remain below the amplifier noise. This is one of the consequences of the fact (mentioned at the beginning of this Section) that the vidicon is not a member of the class of detectors that are best described in terms of their detective quantum efficiency.

Discussion

Figure 7 shows the electrical signal-to-noise ratio and the detective quantum efficiency of image orthicons and vidicons when the camera sees a pattern with contrast between large areas, which pattern is illuminated by light of the optimum wavelength. This figure summarizes the most important results reported in this paper.

The accuracy of the results presented here is not high. The data supplied by RCA were laboratory data not obtained for the purpose of this paper; the rms noise levels are based on peak-to-peak noise amplitudes as observed on an oscilloscope. Since the detective quantum efficiency is inversely proportional to the mean *square* noise voltage, it is clear that there is room for appreciable error in the results. I would estimate that the numbers found are probably between $\frac{2}{3}$ and $\frac{3}{2}$ of the correct values for the image orthicons, and the result for the vidicon may have a somewhat larger range of probable error.

I feel confident that the detective quantum efficiencies found for the image orthicons are approximately correct. I had expected the detective quantum efficiency to be about $\frac{1}{2}$ of the responsive quantum efficiency, and the result found accords with this expectation. It is also in agreement with expectations based on the internal parameters for the image orthicons.

The detective quantum efficiencies found in Table I, about 2.5 and 4%, are from a half to a third of the responsive quantum efficiency of about 8%. I share with Dr. Rose the feeling that these high efficiencies are a technical achievement of the first rank. The writer knows of no other image system that can quite come up to this performance. The human eye and photographic negatives both have a detective quantum efficiency under the best conditions of about one per cent.[9,10]

The new image orthicon with the tri-alkali cathode[11] (RCA 7037) has a responsive quantum efficiency of 19.2% at 400 mμ, and there is every reason to expect that such tubes will have a detective quantum efficiency approaching 10%.

To summarize: Figure 7 shows the signal-to-noise ratio and the detective quantum efficiency of the three image tubes discussed in this paper. The maximum signal-to-noise ratio of the vidicon is slightly higher than that of either of the image orthicons, but the detective quantum efficiency of the vidicon is much lower, because the illumination required to achieve the high signal-to-noise ratio is so much larger.

Acknowledgment

The chief acknowledgments have already been made in the preceding sections. This paper could not have been written without the substantial help of those mentioned, particularly A. D. Cope, George A. Morton and Benjamin H. Vine.

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A Study of Factors Influencing the Legibility of Televised Characters

By WARREN F. SEIBERT, DUANE F. KASTEN and JAMES R. POTTER

Thirty-six volunteer subjects, screened for normal visual acuity, viewed televised displays during a one-hour testing session. There were 252 displays; each consisted of four characters (letters and numbers) of a given size and contrast condition. The study design made it possible to compare visibility across: (1) six viewing distances, (2) three viewing angles, (3) three figure-background contrasts, (4) four character sizes and (5) three time-segments within the testing session. Results indicate that no visual fatigue occurred, that black-on-white and white-on-black contrasts produced about equal visibility, and that characters subtending 10 min of vertical visual angle could be perceived with almost complete accuracy.

Many questions concerning effective visual communication can arise in the course of attempts to use television as an instructional medium, particularly in a classroom. In these attempts, one should consider such factors as the sizes of receivers that are necessary or desirable, the number and positioning of students to be served by a receiver, the sizes and contrast conditions of the informational images presented and many other possible factors influencing the effectiveness of medium. In view of the substantial growth of televised instructional activities in the past half-dozen years and of the possibility that these activities may continue to grow, influencing still larger numbers of learners, it seems necessary to work toward the more adequate solution of these unique problems in effective communication.

An early study by Lewis[1] provides some information of interest to those concerned with effective televised communication and instruction; however, the nature of the equipment used and the nature of the visibility criterion — viewers' subjective judgments — are deterrents to the application of the findings. His interpretation of results suggests, for example, that a 16-in. classroom television receiver may be viewed from a distance as great as 23 ft and that it may serve 30 students (or perhaps as many as 75 students). On the basis of results from the present study and some familiarity with the content of televised instruction, his suggestions seem to overestimate considerably the maximum acceptable viewing distance and the number of students that might be effectively served by a receiver of this size.

Ash and Jaspen[2] report on the use of the Telekit (a 16mm rear-screen projection device with a 13 by 18-in. screen) to present an instructional film to students situated at several angles and distances from the screen and receiving the presentations under one or the other of two illumination levels. These authors tested for the effects of the varied conditions by means of a performance evaluation that was related to the instruction. From their results they concluded that the optimum viewing area for the Telekit was within 30° on either side of a line perpendicular to the screen and within a distance equal to 12 screen widths. They close by stating: "The findings of this study would seem to be relevant to the viewing of television . . ." (Ref. 2, page 12). Conclusions based on data from the present study are in general agreement with the Ash and Jaspen statements.

A third study, reported by Jackson,[3] classifies a group of instructional television visuals as excellent or unsatisfactory and then proceeds to analyze the differences in characteristics of the two classes of visuals. Among his derived visual principles is the statement, "Letters, numbers and important detail should always be light against a dark background" (Ref. 3, page 23). Results from the present study fail to support this statement and indicate, instead, that greater legibility is more likely to be obtained with characters that are dark against a light background.

Purpose of the Study

Two principal considerations underlie the present preliminary study and the plans out of which it developed. First, during early trials of televised instruction* there was an increasing awareness of the shortage of information that could be relied upon to describe suitable (or better yet, optimal) viewing conditions for groups of television students. It was felt that rules of thumb were inadequate and, in addition, that few of the available recommendations in this area could be related to reliable experimental evidence. Second, it was obvious that visual information could not be communicated to students except when conditions permitted their accurate perception of the transmitted information. A visual message that is "below the threshold" for the individual student will not have its intended effect.

In brief, the purpose which developed was one of gathering information that would permit an experimentally based, yet preliminary, statement of conditions under which visual material can be effectively transmitted to student groups via the television medium. As the following and more detailed account of experimental conditions will show, the factors or variables whose effects were studied were: (1) the distance from which televised materials were viewed, (2) the angle from which the materials were viewed, (3) the size of the images viewed, (4) the figure-background contrast conditions of the materials and (5) the elapsed time since the beginning of the viewing period.

Procedures of the Study

The sample of subjects for this study consisted of 36 volunteer college students who had been screened on both near- and far-distance binocular visual acuity prior to the data-gathering session. The Bausch & Lomb Ortho-Rater was the instrument used in screening, and subjects were accepted for inclusion in the sample only if they scored 10 or higher on both the near- and far-distance acuity measures. The average near-distance acuity score for the sample was 11.39 and the average far distance score was 12.14. Twenty-three reported that they did not wear glasses; five that they wore glasses both for reading and driving; six, for reading but not for driving; and two, for driving but not for reading.

The 36 subjects ranged in age from 17 to 35, with an average age of 20.86; and of the 36, 11 were women. The major areas of study for these college students covered a considerable range and included 7 students from Industrial Economics, 6 from the Schools of Engineering, 5 from Psychology, 4 who were unclassified or undecided as to major field of study, and 14 who were distributed among nine different curricular

* At the time when the need for this study first became apparent, professors at Purdue University were exploring the use of televised instruction in introductory physics, a junior-level mechanisms course in mechanical engineering and the first-semester calculus course. It seemed that the effectiveness of each of these courses (and of many others that were not undergoing trial) was partially dependent on the effectiveness of attempted communications of visual information. The experience with these courses precipitated the search for information concerning the visibility and/or legibility of televised materials.

Presented on October 22, 1958, at the Society's Convention in Detroit, by Warren F. Seibert (who read the paper), Duane F. Kasten and James R. Potter, Audio-Visual Center, Purdue University, Lafayette, Ind.
(This paper was first received on September 10, 1958, and in final form on June 5, 1959.)

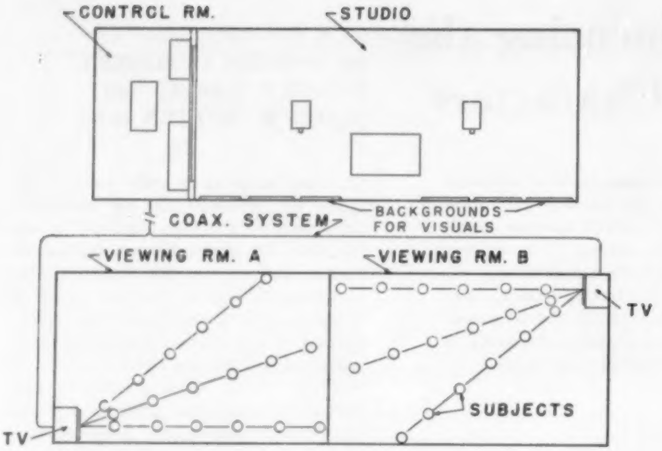

Fig. 1. Schematic diagram of physical arrangements.

areas. Each of the 36 was randomly assigned to one of the 36 viewing stations that had been established (Fig. 1).

The physical facilities and equipment used in the study consisted primarily of closed-circuit television origination facilities in a 20 by 40-ft studio and adjoining control room, a coaxial interconnection system and two 19 by 28-ft television receiving classrooms each containing 18 tablet armchair viewing stations. As Fig. 1 shows, two television cameras were used; these were RCA TK-11A models. The two television receivers were pedestal-mounted, 24-in. RCA console models, and their picture-tube centers were approximately 6 ft above floor level.

The 90mm lens on each camera was used throughout the experimental session. Camera dollies were positioned against a rub strip which permitted dollying right and left while maintaining a constant 5-ft distance between camera lens and the material being viewed. Black, white and medium gray 28 by 44-in. poster-board backgrounds† were attached to the studio wall in front of each camera, and a "tray" on each background provided a slot into which the bottom edge of the 3 by 6-in. visual display cards could be inserted. The "trays" were made of the appropriate shade of poster board, they held the visual display cards flat against the backgrounds, and they were positioned so that information on the cards was on a level with the camera lenses.

As Fig. 1 shows, the 18 viewing stations in each of the two classrooms were arranged as three "spokes" emanating from each of the two receivers. The first spoke was on a line running perpendicular to the face of the television receiver; the second was at an angle of slightly more than 19°, and the third at an angle of slightly more than 38°. The 6 viewing stations within each spoke were arranged to position the nearest viewer at a distance of 6 ft from the receiver, the farthest viewer at a distance of 25 ft and the 4 intermediate viewers at distances of 3.8 ft from viewers in front and behind.

The visual displays presented for viewing and recording by the students consisted of 4-character groups of numbers and/or letters on a 3 by 6-in. card of black, white or gray poster board. Excluding the 4 practice-exercise visuals that preceded the data-gathering portion of the experimental session and the 32 "filler period" visuals, 252 of these 4-character visuals were used in the study. The data of this study are the subjects' records of what they "thought they saw" as each visual display was presented. One third of the 252 visuals consisted of black characters on the white background, one third consisted of white on black, and the remaining third were white on medium gray. Also, as will be seen later, equivalent thirds of the visuals appeared during the first, middle or last time-segment of the experimental period.

The characters used in the visuals were Futura Medium upper case (capitals) and were obtained from Artype, Inc.‡ In order that each of the 28 arbitrarily selected characters used for displays might appear once, and only once, within each combination of variable conditions to be studied, the procedures described below were used. First, 28 usable characters were identified by eliminating the letters *i*, *o*, *r* and *z* and the numerals 1, 2, 7 and 0 from consideration; 36 different random orderings of these 28 characters were then prepared. Second, each of the 36 random orderings was assigned to one of the 36 possible combinations of variable conditions (e.g., black-on-white contrast *with* 24-point type *within* the first of the three time portions of the experimental session). Third, each of the random orderings of characters was "chopped" into the seven consecutive 4-character groups which it provided, and these 4-character groups identified the characters that were to constitute each of the 252 necessary visuals.

In preparing the visual displays to be used in the study, 84 cards, size 3 by 6 in., were cut from each of the three shades of poster-board material, and appropriate 4-character groups were affixed to each of these cards. In attaching the characters, approximately three stroke widths were left between the two nearest parts of adjacent characters. When all visual displays had been prepared, those for each of the three time-segments within the session were assembled into their three separate piles, and display cards within each pile were thoroughly shuffled, thus randomly determining the order of appearance of each visual within its assigned time-segment.

The total time devoted to the experimental session with the student-subjects was just over 60 min and may be divided into seven segments, three of which (see 2, 4 and 6, below) served to provide the data for the study. After the students had reported to the classrooms, had been directed to their randomly assigned viewing stations and had received individual copies of the 16-page answer form, the order, duration and purpose of the seven time-segments were as follows.

(1) Approximately 8 min were devoted to a brief televised introduction to the study and to the presentation and explanation of four practice exercises.

(2) A period of 14 min and 20 sec was spent in presenting the first 84 visual displays and in having subjects record immediately their "best estimates" of the contents of each visual. The exposure time for visuals in this time-segment and in segments described in 4 and 6, below, was 10 sec. After each group of 21 visuals, the subjects were allowed an extra 5 sec to turn pages of their answer forms; for all other visuals in this segment and in the segments described in 4 and 6, below, they proceeded directly from one visual to the next, with no time between the 10-sec exposures.

(3) Approximately 5 min was devoted to a "filler period" during which 16 "oversize" (72-point type) visuals were presented. Exposure times for the individual visuals were 12 to 15 sec. The larger size of the visuals and the longer exposure period provided subjects with a brief "breathing spell," and the period served as a hedge against possible timing flaws in the earlier time-segment.

(4) Another 14 min and 20 sec was

† Poster-board material for the backgrounds and for the 3 by 6-in. visual display cards was obtained from the Dick Blick Co., Galesburg, Ill. The black material was listed as No. 1221, extra dull; the white was No. 1234, egg white; and the medium gray was No. 1228.

‡ The Futura Medium characters supplied by Artype, Inc., consisted of black or white characters (as specified) on the underside of transparent self-adhering acetate sheets. The four type sizes used and their Artype catalog designations were 60-point (1158 and 1159), 48-point (1008), 36-point (1004) and 24-point (1209).

spent in presenting the second 84 visual displays and in having the subjects record immediately their "best estimates" of the contents of each visual. The exposure time and other conditions were the same as in (2), above.

(5) Approximately 5 min was devoted to a second "filler period" as described in (3), above. As with the earlier "filler period," responses gathered during this portion of the session were not part of the data to be analyzed.

(6) Finally, 14 min and 20 sec was spent in presenting the third and last group of 84 visual displays and in having the subjects record immediately their "best estimates" of the contents of each visual.

(7) Following the presentation of the third and last group of 84 visual displays, the experimental session was concluded with a few closing comments and questions.

Following the experimental session, televised images of a horizontally and vertically arranged ruler were presented over the system by means of the two cameras. By measuring image sizes on the faces of the two television receivers, it was found that the televised images were $^{85}/_{100}$ of the actual size of the rulers in both dimensions. Thus, in later work, a size correction factor of 0.85 has been used. At the close of the session, illumination-level readings were also taken at a number of points within the two viewing rooms.§

Before proceeding to the results of the study, a brief summary of the preceding and detailed statement of experimental procedures seems necessary. It should be recalled, first, that there were 36 vision pretested subjects who were randomly assigned to the 36 viewing stations which had been arranged in the two viewing rooms; viewing stations within each room afforded three different angles of viewing and six different distances within each angle. Second, 84 4-character visual displays were presented during each of the three time-segments of the session and the contents of visuals within each segment were comparable to the contents in other segments. Third, each visual display was composed of randomly selected characters (of a given size and figure-background contrast condition) and appeared at a randomly determined time within its time-segment. Fourth, within each time-segment, angle, distance, size and contrast, performance of the subjects was in terms of the number of characters correctly identified.

§ Sixteen illumination-level measurements were taken with a Weston paddle-type light meter and consisted of pairs of measurements taken at scattered points within each of the two viewing rooms. One measurement in each pair was that obtained as the paddle was held vertically and at eye level, the second was taken with the paddle resting on the work surface of the selected tablet armchair. The "vertical" readings, in foot-candles, were 6.5, 8.5, 10.5, 11.0, 12.0, 16.0 and 23.2. The "horizontal" readings were 25.0, 27.0, 29.5, 30.0, 30.0, 30.5, 31.0 and 38.0.

Table I. Summary of the Analysis of Variance of Data From the 36 Subjects (Ss).

Source of Variance	*df*	*Sum of squares*	*Mean squares*	*Error term*	*F*	"*p*"
MAIN EFFECTS						
Angles	2	3079.6586	1539.8293	(A)	7.00	<.01
Distances	5	44276.0866	8855.2173	(A)	40.24	<.0005
Sizes	3	62526.4336	20842.1445	(B)	538.13	<.0005
Contrasts	2	4101.2136	2050.6068	(C)	126.69	<.0005
Times	2	26.0476	13.0238	(D)	2.48	>.05
INTERACTIONS						
2-Term						
AxD	10	5526.4434	552.6443	(A)	2.51	<.05
AxS	6	232.9903	38.8317	(B)	1.00	>.05
AxC	4	20.3099	5.0775	(C)	0.31	>.05
AxT	4	6.0036	1.5009	(D)	0.29	>.05
DxS	15	7396.7744	493.1183	(B)	12.73	<.0005
DxC	10	1437.6944	143.7694	(C)	8.88	<.0005
DxT	10	23.6654	2.3665	(D)	0.45	>.05
SxC	6	959.1020	159.8503	(E)	17.05	<.0005
SxT	6	60.3977	10.0663	(F)	3.03	<.01
CxT	4	19.5876	4.8969	(G)	2.06	>.05
3-Term						
AxDxS	30	2624.0939	87.4698	(B)	2.26	<.01
AxDxC	20	272.5886	13.6294	(C)	0.84	>.05
AxDxT	20	76.0060	3.8003	(D)	0.72	>.05
AxSxC	12	96.9675	8.0806	(E)	0.86	>.05
AxSxT	12	33.9218	2.8268	(F)	0.85	>.05
AxCxT	8	16.0697	2.0087	(G)	0.84	>.05
DxSxC	30	2136.0655	71.2022	(E)	7.60	<.0005
DxSxT	30	139.9644	4.6655	(F)	1.40	>.05
DxCxT	20	62.6993	3.1350	(G)	1.32	>.05
SxCxT	12	70.6711	5.8893	(H)	2.65	<.01
4-Term						
AxDxSxC	60	794.9481	13.2491	(E)	1.41	<.05
AxDxSxT	60	157.5493	2.6258	(F)	0.79	>.05
AxDxCxT	40	67.4204	1.6855	(G)	0.71	>.05
AxSxCxT	24	38.2455	1.5936	(H)	0.72	>.05
DxSxCxT	60	209.6330	3.4939	(H)	1.57	<.01
5-Term						
AxDxSxCxT	120	257.1167	2.1426	(H)	0.96	>.05
ERROR TERMS						
Ss/AxD	18	3960.8197	220.0455	A		
SxSs/AxD	54	2091.4582	38.7307	B		
CxSs/AxD	36	582.6944	16.1860	C		
TxSs/AxD	36	189.2775	5.2577	D		
SxCxSs/AxD	108	1012.4165	9.3742	E		
SxTxSs/AxD	108	359.1664	3.3256	F		
CxTxSs/AxD	72	171.4557	2.3813	G		
SxCxTxSs/AxD	216	480.3337	2.2238	H		
TOTALS	1295	145593.9916				

Edit. Note: The reader is referred to the standard texts, listed in the References at the end of the paper, for detailed definitions of the terms *df* (degrees of freedom), *F* (F-ratio) and "*p*" (probability).

Results of the Study

Although a rather elaborate five-way classification analysis of variance design ‖ has been employed in testing hypotheses on the data of this study, there are three reasons for tempering one's enthusiasm for such an analysis. First, among the hypotheses to be tested are those relating to obviously influential factors (e.g., viewing distance and image size) that require no additional proof of their significance. Second, a legitimate distinction can be made between statistical and practical significance; the two terms are not synonymous and in a study such as the present one it is probably wise to emphasize the practical significance of the findings, rather than their statistical significance. Third, the analysis includes tests for 26 different interaction effects, 16 of which are 3-, 4- or 5-term interactions; it will be extremely difficult to interpret significant interactions meaningfully or in terms that can be of any considerable practical value. On the other hand, the analysis is based on information gathered under carefully controlled conditions and relates to a series of problems in which a considerable interest can be justified. The clues provided by the analysis may prove helpful in the continuing study of the visibility and/or legibility of televised materials.

An examination of Table I will show that all but one of the five main variables or factors had a significant effect on the legibility of the televised materials. The one noninfluential factor was time. During the first of the three time-segments the 36 subjects recorded 63.7% of the presented characters correctly, the corresponding figure for the second

‖ Most basic texts and reference works in the field of statistics and experimental design include sections devoted to the analysis of variance. The interested reader may wish to refer to Lindquist,[4] Edwards,[5] or Walker and Lev.[6]

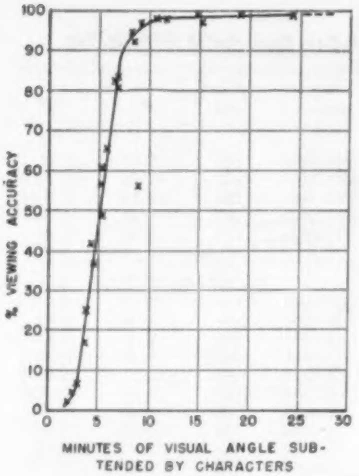

Fig. 2. Relationship between viewing accuracy and vertical visual angle subtended by characters.

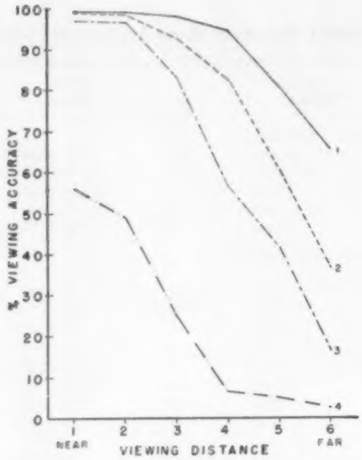

Fig. 3. Plot illustrating the significant size by distance interaction effect.

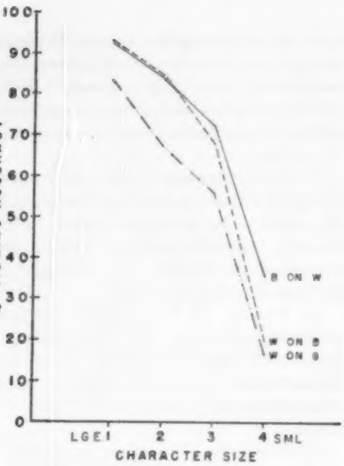

Fig. 4. Plot illustrating the significant size by contrast interaction effect.

time-segment was 64.3%, and it was 65.0% during the last of the time-segments. Performance of the subjects did not alter appreciably over time.

Angle of viewing was a factor contributing significantly to the legibility of the televised materials. The 12 subjects who had direct-line (on-axis) viewing conditions recorded 68.4% of the presented characters correctly; those viewing from an angle of approximately 19° recorded 68.0% of the characters correctly; but those viewing from an angle of approximately 38° recorded only 56.5% of the characters correctly.¶ It is apparent that viewing angle was not a critical factor until it exceeded an angle of approximately 19°; the relationship between legibility and angles of viewing which lie between 19° and 38° cannot be determined from the available data.

Figure-background contrast conditions also contributed significantly to the legibility of the materials. The black-on-white characters were the most legible and the 36 subjects' records showed that 70.9% of such characters were accurately recorded; the corresponding figure for white-on-black characters was 66.3%, and it was 55.8% for the white-on-medium gray characters.

As already mentioned, viewing distance and image size are two factors of known significance, and present results indicate this significance. The subjects seated at the 6-ft distance recorded 88.1% of the presented characters accurately; this declined systematically to 30.2% accuracy for those seated at the 25-ft distance. Similarly, the accuracy for characters in 60-point type was 89.5%, and accuracy was reduced systematically to 24% for characters in 24-point type. The primary reason for including the viewing-distance and character-size factors was to achieve their combination in a "single" variable, the minutes of vertical visual angle subtended by a given size of character when viewed from a given distance. The relationship between visual angle and viewing accuracy is shown in Fig. 2.

By referring to Fig. 2, it can be seen that characters which subtended 10 or more minutes of vertical visual angle for viewers were recorded with just less than perfect accuracy, and characters subtending something less than 10 min of angle were recorded with decreasing accuracy. It is suggested that the one point of the 24 which fails to plot in the region where it might be expected represents a problem in line resolution. This point relates to characters in 24-point type (appearing on the television screen as 0.85 of actual height) and the accuracy of records made by subjects who viewed these characters from a distance of 6 ft. For these subjects the characters subtended a vertical visual angle of just less than 9 min, yet only 56.4% of the characters were recorded accurately. Information from Fig. 2 is discussed further in the final section of the report.

Referring again to Table I and the tests for interaction effects which it includes, it can be seen that ten of the 26 interactions were statistically significant at or beyond the 0.05 level of confidence. The ten significant interactions included five of the ten 2-term interactions, three of the ten 3-term interactions and two of the five 4-term interactions. As a preface to a brief consideration of a few of the significant interactions, it should be stated that each represents the effects of variables *in combination* and each is independent of what may have been found concerning the main effects of the interacting variables. As a demonstration of this independence, it may be noted that two of the significant interactions include the time variable, yet time by itself did not influence performance of the subjects significantly.

Three of the five significant 2-term interactions have been plotted in Figs. 3, 4 and 5. The size-by-distance interaction illustrated in Fig. 3 can probably be accounted for in terms of the "ceiling" imposed by the character sizes or viewing distances used in the study. It can be seen that, at the greater viewing distances, character size had a pronounced effect on legibility; however, at the two nearer viewing distances, the three larger character sizes (shown as 1, 2 and 3 in Fig. 3) were almost equally legible. In short, it appears that the three larger character sizes all satisfied the requirements for legibility equally well when viewed from distances of 6 or 9.8 ft, but as viewing distance increased beyond this, the larger characters became noticeably more legible than the smaller characters.

The size-by-contrast interaction shown in Fig. 4 appears somewhat similar to the size-by-distance interaction. It should be noted that the larger characters were essentially equally legible in black-on-white and white-on-black contrasts; however, particularly at the smallest character size, the white-on-black contrast condition resulted in noticeably less legibility than for the black-on-white. It appears that, if character size was "reasonably adequate," the black-on-white and white-on-black characters were almost equally legible, but when character size was reduced appreciably, the white-on-black characters become much less legible than the black-on-white characters.

The angle-by-distance interaction is graphically shown in Fig. 5 and is the most perplexing of the three chosen for illustration. It will be recalled that the

¶ Application of the t-test for the difference between pairs of means (averages) revealed that performance of subjects who viewed from an angle of approximately 19° was not significantly different from that of those who had direct-line viewing conditions; however, the subjects who viewed from an angle of approximately 38° performed significantly more poorly than those in either of the other two "spokes."

viewing accuracy of the subjects situated in the third (or 38°) "spoke" was significantly less than that of those in the other two spokes. Nevertheless, as Fig. 5 shows, the 38° viewers who were seated at a distance of 17.4 ft from the receivers (i.e., distance "4") were somewhat more accurate in their recordings than were their counterparts in the other two spokes. In addition, it can be seen that the subjects who viewed from an angle of 19° and a distance of 21.2 ft (i.e., distance "5") were noticeably more accurate in their recordings than were counterparts in either of the other two spokes. It is possible that the two "anomalous" points mentioned above are partially the result of the somewhat greater visual acuity possessed by the students in the viewing stations mentioned. It is also possible that illumination levels at these points in the viewing rooms or other, similar factors contributed somewhat to the upward displacement of these performances.

Attempts at plotting and deriving meaning from the significant 3- and 4-term interactions did not prove fruitful and these must remain, for the moment at least, the enigmas which are typical of their kind. The plot of the size-by-contrast-by-time interaction did not reveal any performance displacements that would seem noteworthy; on the other hand, the plot of the angle-by-distance-by-size interaction showed such a variety of displacements that it was impossible to identify the likely source(s) of the obtained interaction effect.

Conclusions and Recommendations

Information gathered during the course of the study and summarized in the preceding pages lends support to the following conclusions:

(1) Persons with average (or somewhat better than average) visual acuity can engage in moderately heavy to heavy TV viewing for a period of approximately one hour without incurring any loss in their ability to perceive and record accurately the information presented on television.

(2) The angle from which televised materials are viewed significantly influences legibility of the materials but it is possible to view from an angle as great as 19° without decreasing legibility significantly below the level obtained with direct-line (on-axis) viewing. Loss of legibility apparently becomes pronounced at an angle between 19 and 38°.

(3) The figure-background contrast conditions of televised characters influence legibility and, under most conditions, black-on-white characters are apparently more legible than white-on-black. White-on-medium gray televised characters are less legible than the higher contrast white-on-black or black-on-white.

(4) Both viewing distance and character size influence legibility of televised characters, and if characters subtend approximately 10 min of vertical visual angle for an individual viewer, they achieve essentially maximum legibility. Characters subtending larger angles are not noticeably more legible, but those subtending smaller angles become increasingly less legible.

Results from this study seem to provide partial solutions to some of the problems in effective visual communication which may accompany the use of television as a medium for classroom instruction; however, in applying the results of the study, there must be an awareness of the differences existing between the present study and the operational use situations. First, student volunteers who supplied data for the study all exhibited a relatively high level of visual acuity; in other groups, such acuity may not be present. Second, results obtained through use of the present "nonsense" visuals should tend to underestimate legibility of meaningful materials such as those presented in the course of instruction. Third, for the present it can only be assumed, not demonstrated, that the characteristics of the TV system used in the study were "typical"; a validation of this assumption is needed.

A pilot study preceded the present study and its results also indicate the importance of the approximate 10-min visual angle. The important difference between the studies (and the reason for the following brief description) was that pilot-study visuals were composed of hand-lettered characters, rather than the seemingly more legible Futura Medium type. Nine subjects participated in the pilot study under conditions similar to those already described (e.g., four character sizes; three viewing angles; but only the viewing distances of 5, 15, and 25 ft). A plot analogous to that in Fig. 2 was made with pilot-study data and showed 75% accuracy at 6 min of visual angle, 88% at 8 min and 96% at 10 min; maximum accuracy was 98% at 30 min. Two of the twelve points in the figure did not plot in the regions expected and these were points representing viewing accuracy of subjects at the 5-ft distance when viewing the two smaller sizes of characters. As with the larger study, they suggest that viewers were not resolving lines on the screen and the lack of resolution was detracting from legibility.

The results of the present study seem not to provide the most satisfactory basis for a statement of minimum acceptable viewing distances, since they deal only with legibility and fail to consider the comfort or preferences of viewers; however, it seems unlikely that viewers will tolerate unresolved lines on the screen over extended periods of time. Thus, the

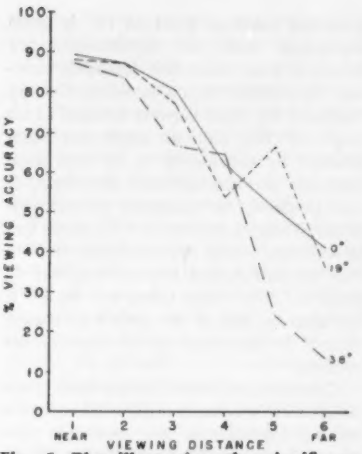

Fig. 5. Plot illustrating the significant angle by distance interaction effect.

minimum viewing distance should probably be great enough to permit resolution. Also, if screen centers are at heights of $5\frac{1}{2}$ to 6 ft above floor level (as seems to be the developing practice), the minimum distance recommendation should take account of the posture that must be assumed and maintained by viewers. With these considerations in mind, a minimum distance of five to six screen widths would seem to be acceptable and not contrary to related information from the present study.

A recommended maximum viewing distance should give serious consideration to the finding that televised characters apparently must subtend a vertical visual angle of approximately 10 min if they are to be consistently legible. Using Jackson's recommendations (Ref. 3, pages 15 and 22) concerning height of characters (i.e., a device should cover about two-thirds of the screen area and characters should be about one-fifteenth of the height of the device), characters on a 24-in. screen would be 0.86 in. high. Characters of this height would subtend 10 min of vertical visual angle when viewed from a distance of approximately 24.5 ft; this distance is the equivalent of 14 screen widths. If it is assumed that a character and the adjacent space are also equal to 0.86 in. and that spaces between lines of characters are equal to three-quarters of the character height, then it would be possible to present 9 lines of characters with 20 characters (or their equivalent) in each line while maintaining essentially maximum legibility at the distance recommended. There may well be instructional situations in which the foregoing restrictions on the quantity of presentable information cannot be accepted. In such cases, one might define the maximum number of character spaces to appear in a horizontal line and use this as a basis for determining the maximum viewing distance.

The information on legibility of televised materials suggests that viewing

from an angle as great as 19° is quite acceptable and not significantly less accurate than direct-line (on-axis) viewing. Since there was a significant loss in legibility for those viewers situated at an angle of 38°, such an angle can legitimately be considered to be less than optimal. In instructional situations, it will probably be necessary to seat students at angles as great as 45°; some loss in legibility can be expected as a result of this but, as Ash and Jaspen state (Ref. 2, page 9): ". . . the losses will be less if the angular size of the area is increased than if the distance from the screen is increased."

Contrast conditions for televised characters were obviously influential in determining legibility of the materials presented in this study, and the two higher contrast conditions resulted in greatest legibility. Although most studies involving direct viewing of materials indicate the greater legibility of black-on-white characters and although present results are in agreement, it seems unnecessary to recommend strongly the use of the black-on-white contrast condition, rather than the reverse contrast. It will be recalled that overall accuracy for black-on-white was 70.9%, while that for white-on-black was 66.3%. With the black-on-white as standard or 100%, white-on-black resulted in accuracy that was 93.5% as great. The more important recommendation would be that low contrasts such as that represented in the white-on-medium gray be avoided when characters must be maximally legible.

In conclusion, the present study is only one of what should be a continuing series of studies aimed at the more adequate identification of optimal conditions for televised instruction. Questions concerning physical arrangements, facilities and the many related problems are being asked repeatedly. Even though other factors play a greater role in the determination of instructional effectiveness, the questions deserve to be answered.

Acknowledgments

The writers gratefully acknowledge the ideas and assistance of several who contributed heavily to this study. They are deeply indebted to James A. Norton, Jr., for his advice concerning the statistical analysis. They are equally indebted to those on the staff of Purdue's TV Production Unit for their assistance in executing the experimental session. It would be impossible to overlook the excellent cooperation of the 36 student volunteers who supplied the data for the study.

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A New Moderately Priced, Practical Television Film Recorder

By WILLIAM O. CRUSINBERRY and LESLIE P. GREENHILL

To meet the request of educators for a simple, moderately priced television film recorder, the Dage KR-11 has been designed using an especially modified single-system sound camera and a monitor with relatively uncomplicated circuits. Controls have been kept few in number, and a simple and reliable method for setting up the recorder has been developed. Single-system sound recording facilities have been incorporated. Several educational applications have been explored.

The decision to design a new 16mm television film recorder was based on the belief that there existed a definite need for a moderately priced recorder to meet the demands of the educational or small broadcaster, or users of closed-circuit television systems. The development of such a recorder was therefore undertaken by Dage, and the field testing was conducted by The Pennsylvania State University.

On the premise that the unit would probably have to be operated and maintained by personnel of limited TV recording experience, it was thought that the design must involve a minimum of complexity in operation and circuitry, and yet provide good quality in the finished print. With these requirements in mind, it was considered that the recording camera itself must be a modification of a standard motion-picture camera adapted to TV recording, and that the electronic circuitry must be designed without the benefit of complex coincidence keying or blanking circuits used in other recorders.

The recorder is *not* specifically intended for network operations or other similar situations where presumably funds and professional engineering skills are available which make the more expensive and complicated recorders a feasible proposition. It is not claimed that the recorder's resolution is as good as that of the fully interlaced or video-tape recorder; but the unit does appear to be thoroughly adequate for many useful purposes, and it should be evaluated in terms of these purposes.

The Recording Camera

Early experiments were conducted with motion-picture cameras that were available on the market, utilizing a TV shutter with an opening of 144°. However, it soon became apparent that, owing to variations in processing control and machining tolerances used in the construction of these cameras, consistently making TV film recordings that did not contain some shutterbar was virtually impossible.

A manufacturer* who had designed a modification of the Auricon camera to adapt it to TV recording was consulted. The modification involved the construction of a special shutter and pulldown arrangement that eliminated the occurrence of video splice during the TV field. This was accomplished by rotating the shutter at 720 rpm or one-half of the film frame frequency and constructing the shutter as shown in Fig. 1. As can be seen, the shutter was designed to provide a 72° open period, which corresponds to the duration of one TV field, followed by a 72° closed period, a second 72° open period and then a 144° closed period.

Figure 2 shows the relationship of the

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(This paper was first received on December 1, 1958, and in final form on April 28, 1959.)

* Television Specialty Co., Inc., 350 W. 31 St., New York 1.

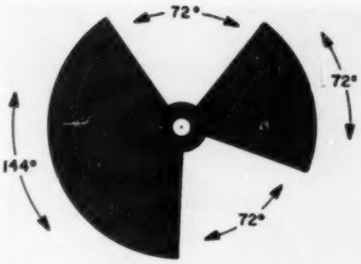


Fig. 1. Design of mechanical shutter of recording camera.

TV field frequency, the shutter action and the film frame rate. The TV field frequency and the speed of the motor which drives the film transport and the shutter are locked by synchronous action, and facilities are provided on the camera for phasing the shutter with respect to the TV fields. When the shutter and the field frequency are phased properly, as shown in Fig. 2, it can be seen that the opening and the closing of the shutter occur at all times during the vertical blanking interval. Pulldown of the film in the gate, of course, occurs always during a closed-shutter period. It is apparent, from Fig. 2, that the first film frame will contain a photograph of an odd field, the second film frame an even field, the third an even, the fourth an odd, the fifth an odd and so forth in the sequence of two odd fields followed by two even fields.

With this system of alternate field recording, picture interlace is accomplished during projection of the film. A static test pattern reproduction will exhibit a slight moire effect or line beat; however, considerable research into practical applications of the recorder has shown that this effect is not objectionable in the recording of the dynamic scenes of normal program material.

Since the opening and closing of the shutter, when properly phased, always occur during the vertical blanking period, it is virtually impossible for shutter-bar or banding to be photographed. Under normal operating conditions the recorder is capable of reproducing on film 600 lines of horizontal resolution and about 350 lines of vertical resolution using the Dage Model 320 vidicon cameras and EIA resolution test chart.

Controls and Specifications of the Recorder

Figure 3 shows the Dage KR-11 recorder with the doors removed. The unit is entirely self-contained in one housing, standing about 38 in. high at camera loading level, 33 in. wide and 17 in. deep. The picture tube itself is mounted in the housing on the left and is recessed back from the opening through which the camera shoots to reduce ambient light problems.

The audio amplifier is mounted in the housing above the tube, and the operating controls for the camera are in front of the housing. Inside the cabinet to the left are the monitor operating controls. The four controls at the top are for video level or contrast, bias or brightness, focus and polarity reversal. The remaining controls are screw-driver adjusted controls for centering, linearity and size.

The meter on the front panel reads the second anode voltage applied to the picture tube. Metering jacks provided on the front panel for the measurement of bias and video drive may be used for purposes of setup and exposure control. Access panels are provided at the back and on the sides for maintenance purposes. Access to all tubes and components of the monitor and power supplies is provided without removal of the chassis from the cabinet.

The picture tube of the recorder is a 5WP11 operating at about 25 kv from a regulated and variable high-voltage power supply. The focus voltage for the tube is obtained from the same supply and, of course, is variable and regulated.

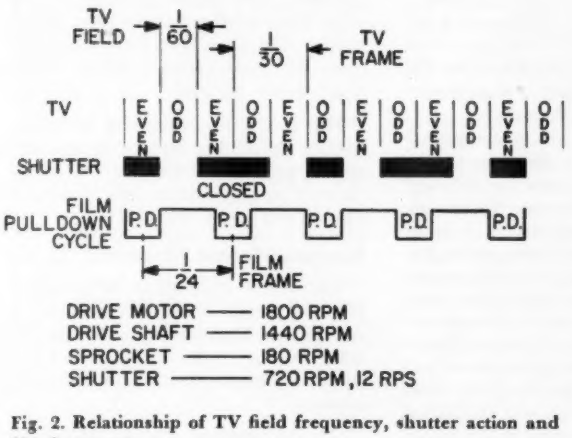


Fig. 2. Relationship of TV field frequency, shutter action and film frame rate.

Fig. 3. External view of Dage KR-11 TV film recorder with doors removed. The audio amplifier and its controls are located above the housing which encloses the picture tube on the left of the recorder. The recording camera with its 1200-ft magazine is located to the right.

Fig. 4. Studio scene showing black-and-white card located on set for the purpose of adjusting the brightness and contrast controls on the recorder prior to the making of a recording.

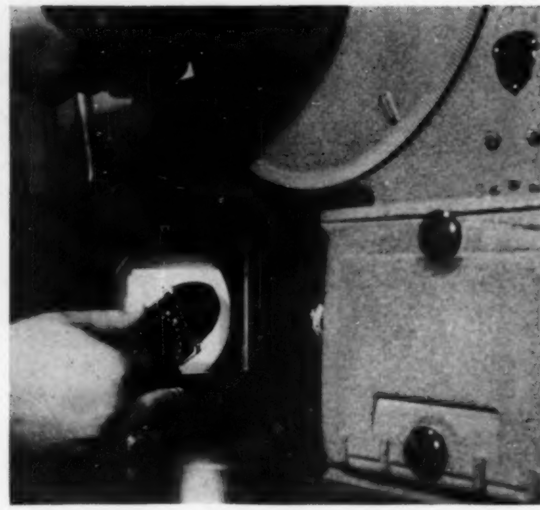


Fig. 5. Brightness and contrast controls are adjusted so that the image of the black-and-white card gives predetermined levels of brightness when measured by an incident light meter.

The regulated low-voltage supply for the monitor, the supply for the audio amplifier and the sound exposure voltage supply are located in the righthand section of the cabinet.

A thermal time delay provides protection to the phosphor by preventing application of high voltage until 30 sec after low voltage is applied.

The input requirements to the recorder are 1.4-v p-p composite video, which may be looped through or terminated at the recorder. In addition, facilities are provided for feeding horizontal drive pulses directly to the recorder. Audio input for the single-system sound recording amplifier may be low-impedance microphone, or the unit may bridge the 600-ohm program line of any audio console.

The monitor contains an 8-mc bandwidth video amplifier, keyed clamping and a polarity switch for either positive or negative image recording.

The power consumption is 650 w at 115-v alternating current.

Setting-up Procedures

The original plan was to set the brightness and contrast levels of the recorder by adjustment of the bias voltage with the aid of a vacuum-tube voltmeter and adjustment of the video drive with the aid of an oscilloscope, and some users still prefer this method.

However, this procedure proved to be difficult for several reasons: (1) The bias voltage setting was found to be a very critical adjustment, and rather difficult to determine consistently from one time to another owing to variations in the accuracy of the average vacuum-tube voltmeter; (2) video drive was also difficult to determine accurately with the use of an oscilloscope, especially by a nontechnical person; and (3) this method did not take into account the aging of the picture tube in the recorder.

For these reasons this procedure was abandoned in favor of a simpler and more reliable method. This method involves the use of a standard object—a matte black-and-white card—which is positioned in the studio in the area where the principal action will occur. Readings of the brightness of the image of this card are taken directly from the face of the picture tube with a standard photoelectric incident light meter, and adjustments are made on the recorder to achieve predetermined levels of brightness for black and white. Since the method has been tested and adopted successfully by a number of users, it might be worth while to review it briefly here.

In actual practice the setting-up procedure requires the following four steps:

(1) An 18 by 24-in. card, half matte black and half white, is positioned on the set in the area where the principal action is to occur as indicated in Fig. 4. A TV camera is focused on this card so that its image completely fills the screen.

(2) The pedestal is set to the normal level (we use 10%) on the camera control console. The camera controls are then adjusted to provide exactly one volt of video output as indicated by the peak of the waveform of the white card as displayed on the "A" scope of the master monitor. Readings are then taken from the face of the picture tube in the manner shown in Fig. 5, using a Norwood Director light meter with the photosphere and light baffle removed. Readings are taken with the meter in contact with the face of the tube (the metal parts of the meter body are covered with felt to prevent scratches on the tube). The brightness and contrast controls are adjusted until readings of predetermined values are obtained from the black and the white image of the card. In making these readings, care is taken to ensure that all equipment is warmed up to stable operating temperatures.

(3) The pedestal level of the second camera is then set so that it corresponds exactly to that of the first camera. This is generally achieved by measuring the brightness of the pedestal level (with no video signal) from the face of the picture tube and adjusting the blanking control on the second camera so that it provides a brightness level on the tube which matches that of the first camera. It has been found that small variations in pedestal levels between the two cameras can seriously affect the balance of the pictures between the TV cameras.

(4) The *f*-stop of the recorder lens is checked, and the recorder is ready for operation. Care is taken to adjust camera video levels during the recording operation so that the whites in a scene just reach the one-volt level on the "A" scope of the master monitor.

This procedure has proved to be extremely simple and reliable in practice, and it provides satisfactory compensations for variations in the age of the picture tube of the recorder.

Laboratory Control Procedures

The actual readings to be obtained from the image of the black-and-white card as read from the face of the picture tube were determined from a series of practical tests carried out in the following manner:

(1) The pedestal was set up to the normal 10% level. A picture of a typical scene was then established on the camera control monitor so that the whites in the scene provided a signal of one volt. (Highlights or specular reflections were allowed to ride over the one-volt level.)

(2) The recorder's controls were then

adjusted to provide a fairly bright picture on the tube with moderate contrast, but with no trace of flare or bloom. The black-and-white card was then substituted for the live scene, and readings were made with the light meter in contact with the face of the picture tube. The live scene was again substituted, and several feet of film were run at different settings of the *f*-stop of the lens in the recorder. (The focus of the recorder camera lens was previously established by running tests at different footage settings and selecting the best setting by examination of the resulting negative.)

(3) The test film was then processed by a laboratory to a gamma recommended by the manufacturer of the film. Most of the work at The Pennsylvania State University has involved the use of Eastman Television Recording Film, Type 7374. This negative film has been consistently developed to a gamma of 0.80 + 0.02.

The best possible prints were made from these test negatives and were developed to the normal print gamma adopted as a standard by the laboratory— usually in the region of 2.40.

The resulting prints are projected either directly or over a TV film chain, and the preferred one is determined. An *f*-stop is selected for the recording camera which gives a negative with a density of not less than 0.20 in areas requiring printable detail. Some additional tests at different settings of the recorder may be required to achieve the exact contrast desired. In each instance readings are made of the black-and-white card, and laboratory processing procedures are held constant. Once the desired negative and print quality has been achieved, it has proved to be a relatively easy matter to obtain consistent results with the recorder, using the procedure described earlier. At The Pennsylvania State University two different types of film have been used: Eastman Television Recording Film, Type 7374, and Du Pont Reversal Film, Type 930A. The readings from the black-and-white card made with the Norwood meter used in the manner indicated have been: white 400, black 40, *f*-stop 2.5 for Type 7374 film; and white 400, black 16, *f*-stop 4.0 for Du Pont 930A reversal film. The actual readings to be used in a given instance will be a function of the contrast range desired in the final print, and the gamma to which the laboratory processes the negative and print. The foregoing figures are intended only as a rough guide.

Sound Recording

The recorder provides for the recording of single-system sound on film. Satisfactory results have been obtained using both Eastman Television Recording Negative Film, Type 7374, and Du Pont 930A Reversal Film. In the case of the 7374 film, tests were made at several different sound exposure settings, and a setting was chosen that yielded a sound-track density of between 1.0 and 1.2 when the film was developed to a gamma of 0.80.

With the Du Pont Reversal Film, tests were made using typical sound inputs at several different exposure settings. After the film was reversal-processed, the exposure setting was selected that was judged to yield the most pleasing sound.

When a large number of prints is needed, or when any editing is contemplated, double-system sound recordings are made by means of a Stancil Hoffman S-5 16mm magnetic film recorder.

Studio Lighting

The Dage KR-11 recorder has been used in conjunction with the Dage 320 professional vidicon camera chains using type 6326 vidicon tubes, and careful attention has been paid to studio lighting in order to obtain satisfactory TV film recordings. At The Pennsylvania State University sets have been illuminated to an even 250 ft-c of incident front light as read on the Norwood light meter. This level is achieved with a mixture of incandescent spotlights and scoops, and two 4-tube slimline fluorescent units. Side and back lighting are arranged to give a level of about 300 ft-c. Thus, the ratio of front lighting to back lighting is approximately 1:1.25. A lens opening of *f*/2.8 is used on all the TV camera lenses.

Educational Applications

A number of important uses of film recordings produced on this moderately priced recorder have been developed.

One application is designed to extend instruction off the main university campus. In this connection the core materials of two college courses, College Chemistry I and Introductory Psychology, were recorded on film at the request of the Information and Education Division of the Department of Defense for use in conjunction with the correspondence courses of the U.S. Armed Forces Institute. The chemistry course included 20 half-hour lessons, and the psychology course covered 16 half-hour lessons. These TV film recordings are being broadcast over the TV transmitters of the Department of Defense and are being used as audio-visual materials at military bases. The volume of usage of the series indicates that the recordings are entirely adequate for the purpose. Plans are also being made to use these same recordings to supplement the instructional resources on the University's branch campuses which are scattered over the state of Pennsylvania.

A second use of these recordings is for the self-evaluation of instructors. In a number of instances recordings have been made of typical sample lessons given over the University's closed-circuit TV systems to enable professors to evaluate and improve their own instructional techniques.

Several professors have also expressed interest in having all or parts of a course recorded for future use. A limited number of lessons have been so recorded and the recordings used in subsequent semesters. This application is one that may increase greatly in the future if the growth in college enrollments continues to run ahead of the supply of teachers. It would appear to be appropriate for courses that do not change radically from one semester to the next, and for subject areas where there is an acute shortage of skilled teachers.

Another use that has been made of TV film recordings is for public information purposes. Recordings that depict a variety of university activities have been produced rapidly and economically. These cover a wide range of topics extending from ionospheric and metallurgical research to the work of the speech clinic and to agricultural subjects. These recordings have been accepted and shown by commercial television stations throughout the state of Pennsylvania.

In summary, it can be said that this TV film recorder fulfills an important educational need and is compatible with vidicon TV equipment in that it is relatively simple to operate, is reliable in service and produces 16mm film recordings of a quality which is quite adequate for classroom use and TV broadcasts.

A Television Workshop as an Agency Client Service

By WARREN G. SMITH

The general layout of the Workshop, which was established in New York in 1954 by the J. Walter Thompson Co. to provide a testing-ground for commercial ideas, is given, and then the studio, control room, and editing room and their equipment are described. Maintenance equipment, power services and viewing facilities are outlined. Live and film television, both monochrome and color, sound and video recording, animation, stop-motion and other special effects, as well as experimental and developmental work, are among the activities of the Workshop.

The costly and time-consuming factors that may lie between the original concept of a television commercial and its completion sometimes cause good ideas to die in their infancy. The J. Walter Thompson TV Workshop provides facilities for producing high-quality test commercials at a saving of time and money. Creative groups within the advertising agency that established the Workshop in 1954, using it to test their ideas, often have found entirely different and more effective methods of presentation than those originally conceived. Agency personnel can view auditions of talent or pilot films under actual broadcast conditions. Flaws are picked up and eliminated, recommended changes can be made immediately, and clients may see what the commercial will look like to TV audiences before incurring the costs of final production.

Presented on October 22, 1958, at the Society's Convention in Detroit, by Warren G. Smith, J. Walter Thompson Co., 420 Lexington Ave., New York 16.

(This paper was first received on October 2, 1958, and in final form on June 29, 1959.)

Typical activities carried on in the Workshop include live action filming, animation, time-lapse and lip-synchronization photography, stop-motion, TV film recording, monochrome and color closed-circuit TV (live and film), sound recording, talent screen tests and rehearsing of live TV commercials.

The Workshop, located in the Grand Central Palace Building, is linked with the agency's main New York offices, two blocks away, by video, audio and private telephone lines. For eighteen months after its inception, the Workshop occupied a small studio and its equipment was modest, consisting of a 16mm single-system camera, a tape recorder, a 16mm film projector, equipped with TV shutter, and a single monochrome vidicon camera chain, which served for both live and film pickup. Lighting equipment, audio accessories, props and scenery were confined to essentials. Three men were employed, two full-time, one part-time. In December 1955, the Workshop was moved to its present larger, custom-constructed studio area, and the equipment was modified, modernized and expanded to increase the services potential to the client. Seven men are now employed under the supervision of a general manager.

Workshop Layout

The studio area (Fig. 1) is 60 ft long, 40 ft wide, and 16 ft high. The walls and ceiling are soundproofed with 2-in. thick, 24-lb glass-fiber batts. The concrete floor is overlaid with asphalt tile. Two columns in the center of the studio support lighting circuit breakers, microphone input jacks, equipment power outlets and scenery building accessories. An overhead lighting grid was installed during studio construction. The control room is in one corner of the studio and another corner is used for storage of lights and scenery. Talent dressing rooms and storage closets are located along a short hallway between the studio and editing room. The maintenance shop and air-conditioning room are situated at the rear of the studio, and a double doorway in this corner leads to the building freight elevators, permitting the movement of large pieces of scenery or props to and from the

Fig. 1. Overall view of the TV Workshop, showing sets and equipment; permanent kitchen set (left rear) and control room (right rear).

studio. Since many of the clients' products are used in the kitchen, a permanent kitchen set was installed in the studio. The counters are mounted on casters, and the functional units are connected to cables and hoses, for rearrangement purposes. The set is finished in yellow, rather than white, to reduce live TV pickup problems. Sets may be constructed on the other walls.

The use of elaborate scenery and props is kept to a minimum; however, there is a prop room with 1600 sq ft of storage area.

Studio Equipment

Film Cameras

A 16mm Auricon Super-1200 camera, with noise reduction, variable-area sound and TVT shutter, is used. Live filming and TV film recording are accomplished with this unit, which is usually mounted on a Fearless Panoram dolly, equipped with a Worrall gear head, although various tripods and friction heads are available. An Eastman Kodak 16mm Cine-Special II is employed for stop-motion, animation and other special effects. Most effects are made in camera or on set for speedier results.

Because it can be processed and returned in as little as two hours as a fine-grain reversal print, Eastman Plus-X Reversal Film, Type 7276, has been chosen for most black-and-white work. Commercial Ektachrome is used for color jobs. During the last four and a half years, more than three million feet of film have passed through the cameras.

A matched set of eight Kodak Ektar 16mm "C" Mount Lenses, ranging in focal length from 15 to 63mm, has been provided for film and TV camera use. A Pan-Cinor 20-70mm zoom lens is also included.

Lighting

The need for flexibility of lighting setups, speed and ease of light handling dictated the use of incandescent lighting equipment. Spots, scoops, broads and cones, in wattages ranging upward to 5 kw, plus such items as scrims, snoots and "cookies," are available. In addition, four banks of overhead 150-w birdseyes were installed. These can be varied in height and position by a cord and pulley arrangement. They are used in conjunction with two Colortran transformers. For special effects, the studio has ultraviolet and infrared light sources available.

Television Equipment

Vidicon camera chains, because of their small size, low power requirements and ease of maintenance, were found to be ideal for the Workshop's purposes. One Dage 360-B, 3-V color camera, and two Dage 300-D monochrome cameras are included in the present setup. Any of these units may be used for either live or film pickup. Two cameras are equipped with lens turrets. The color camera's turret is electrically operated and may be rotated from its control position.

Fig. 2. Miniature props, lighting, and Cine Special II produce special flying effects.

Although the monochrome cameras are equipped with electronic viewfinders, a floor monitor serves adequately as viewfinder for the color camera. Three monitors are situated in the studio area — two monochrome, one color. For TV film recordings produced in the studio proper, a Dage 600-A 14-in. monitor is used as the display device. A Sylvania 21-in. receiver, modified to handle either video or r-f signals, serves as both an off-the-air monitor for kinescoping commercials and as a studio monitor. For color viewing, a 21-in. color receiver, modified to accept an encoded NTSC signal, acts as the third floor monitor.

A two-speed turntable and amplifier, built into a mobile cabinet, is employed in the studio and control room for music and sound effects.

Control Room

The control room is constructed of cinder block, with a concrete plank

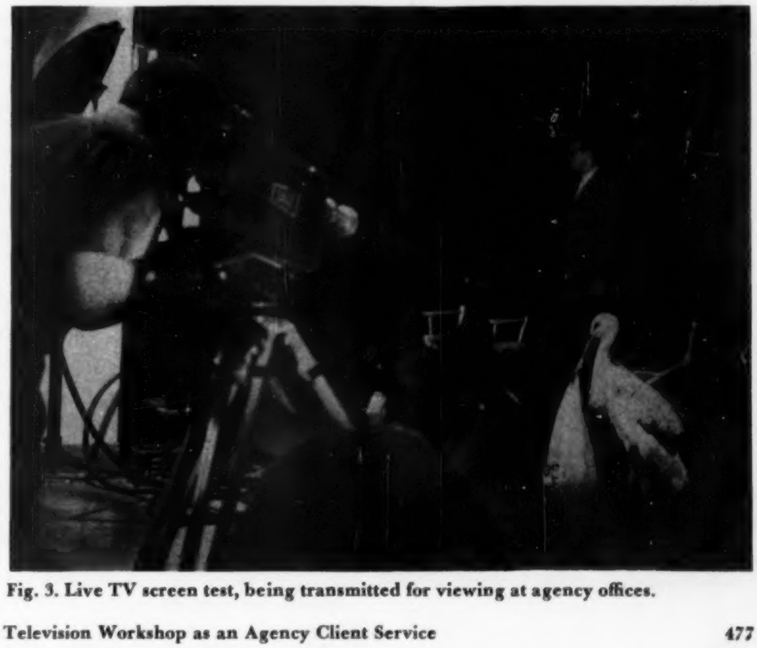


Fig. 3. Live TV screen test, being transmitted for viewing at agency offices.

Table I. Electrical Equipment and Power for Studio (S) and Control Room (CR).

Equipment	*Service*
Lighting (S)	115-v d-c, 400 amp
Monochrome video (CR)	115-v a-c, 10 amp (regulated)
Color video (CR)	115-v a-c, 30 amp (regulated)
Audio and Projection (CR)	115-v a-c, 40 amp
Floor equipment and Colortran lighting (S)	115-v a-c, 220 amp
Mitchell camera outlet (S)	209-v a-c, 3-phase, 15 amp
Kitchen set (S)	220-v a-c, 90 amp
Air Conditioning (13 tons)	209-v a-c, 60 amp

ceiling. It encloses an area of 120 sq ft in which video, audio and projection equipment has been installed. Perforated acoustic tile soundproofs the walls and ceiling, and double windows have been placed in two of the walls.

Video Equipment

Monochrome and color synchronizing units are contained in one cabinet rack, together with a color encoder and power supplies. Another rack contains a color-shading generator, filter, and power supplies.

Film and slide material is projected into the video system by a JAN 16mm film projector and a Selectroslide Jr. slide projector, working into a multiplexer. Both projectors can be operated from the video console.

The camera controls, with their associated monitors and "A" scopes, are console-mounted. Switching is accomplished by a four-position, two-bank unit, with clip, fade, dissolve and superimpose controls. The driven clamp had to be modified and "softened" to allow passage of the subcarrier burst during color transmission. Camera control and switching consoles are arranged for one-man video, switching and projector operation.

Audio Equipment

A custom-built mixer, accommodating three low-level microphone inputs and one line input, with dialogue equalization, feeds a Magnecord M-80 tape recorder and amplifier. In addition to its primary function, the recorder amplifier serves several other purposes. Used in conjunction with the Auricon amplifier, it delivers audio to the film camera for single-system recording. Sound is fed, through the unit and an RCA line amplifier, to the radio line linking the Workshop to the agency's main offices during telecasts. For re-recording optical to magnetic track, and either optical or magnetic to a striped print, it acts as control amplifier for two synchronous projectors. A Fairchild synchronous track generator allows use of the recorder for double-system sound.

Other control-room audio equipment includes a Bogen utility amplifier (for intercom talk-back from either the main offices or the control room to the studio area), switching and patching panels, and an FM tuner for off-the-air recordings.

Editing Room

This area is supplied with a standard complement of editing equipment, including an Eastman Kodak Model 104M Pageant 16mm projector, which is capable of optical playback, plus magnetic record and playback. The unit has been modified, with the addition of a synchronous motor and belt drive, to perform an extra function in studio operations. Use of the projector as a synchronous magnetic re-recorder has enabled the Workshop to film a test commercial double-system, edit, re-record, and have a finished product, ready for client showing, all in two working days.

A custom-built animation stand is employed, with the Eastman Kodak 16mm Cine-Special II camera, to produce representations of animation ideas.

Maintenance

The maintenance shop is provided with a wide variety of test equipment for video and audio servicing. Tools and hardware for set construction are also included in this area.

Tubes are the largest single item of the spare parts inventory. Other replacement components are readily obtainable from several nearby radio and TV supply houses.

Power

Table I designates the electrical equipment used in the Workshop and the power services available for its operation.

Viewing

Video and audio signals originating at the Workshop are carried by Telco facilities to the main offices, where they are used to modulate a Channel 3 closed-circuit transmitter. The r-f output of this unit is fed through a wired distribution system to six monochrome and three color receivers in six viewing areas. Intercommunication between the main offices and the Workshop is accomplished either by private telephone line or, with the assistance of a pickup coil and amplifier, by regular telephone extension. In this manner, suggestions and changes in the material being viewed may be directed from any of the viewing positions.

Personnel

The Workshop is operated under the supervision of a general manager, William Whited, and has a working staff of seven men who have had many years of professional experience. They are employed in the following capacities: film cameraman, television engineer, sound engineer, projectionist and electronic technician, electrician, set builder and property man, and film editor.

An Automatic Additive Color Printer

By HANS-CHRISTOPH WOHLRAB

Solenoid-operated vane-type shutters in the printer control the red, green and blue beams split up from the white light by dichroic mirrors. The color light values and the fader-speed information are fed into the printer by a perforated tape, which also starts and stops the printer. Notches in, or aluminum patches on the film release the information prestored in a memory device to the light controls. Accessories and a sound printing head extend the flexibility of the printer.

BELL & HOWELL PRINTERS, type D (35mm) and type J (16mm), are almost classical equipment in hundreds of film processing laboratories in the United States and in countries all over the world. They are single light source printers and have done such a good job that their design has been practically unchanged for more than thirty-five years.

The introduction of color limited the use of these printers. Only basic filter-pack compensations could be made because the changing of color balance during printing was beyond their facilities.

In considering the design for a new printer that would meet the specifications of a modern color-film laboratory, the fundamental question to be decided was: Subtractive or additive color control? In subtractive printing, one single white beam is color-controlled by inserting filters that subtract the colors to be increased on the print. In additive printing, the white light is split into three beams (red, green, blue), which are controlled separately in intensity and eventually reunited ("added") in the printing aperture. It is evident that equipmentwise the subtractive system is simpler and that a single-light black-and-white printer can be transformed into a subtractive printer without fundamental changes. Additive printing requires a more complex piece of equipment, but eliminates the time-consuming preparation of filter packs because light control can be effected by electromechanical means. The three fundamental colors, once established, stay in their wavelength range and do not depend on different hues of gelatine filters. Also, as color experts confirm, additive printing can yield even better results than subtractive, if properly handled.

In designing a new printer prime consideration must be given to maintenance of quality as well as to fast, easy and reliable operation. The latter leads to high-speed printing and automation.

Presented on October 20, 1958, at the Society's Convention in Detroit by Hans-Christoph Wohlrab, Bell & Howell Co., 7100 McCormick Rd., Chicago 45. This paper supersedes that presented at the Society's Convention in Philadelphia on October 4, 1957.
(This paper was received on March 31, 1959.)

The Optical System

The "white" light of one 1000-w incandescent lamp, after passing heat filters and the condenser system, is split by dichroic mirrors into the three fundamental color beams: red, green and blue. Dichroic mirrors have a multilayer surface, the thickness and material of which are selected in such a way that through the effect of light interference one specific color band is reflected and the remaining part of the light is transmitted through the mirror with practically negligible loss. This results in a much higher light efficiency than can be obtained with light-absorbing color filters.

The first mirror (Fig. 1) reflects red and transmits green and blue. Mirror No. 2 can reflect yellow (red plus green) but red already having been taken out of this beam, it reflects green only. Mirror No. 3, which reflects blue, could have been a silver-surface mirror, because only one color is left for it, but a dichroic mirror provides an additional useful decrease in bandwidth.

In each color beam the light intensity is controlled by a vane-type shutter, the position of which is determined by a solenoid-operated device. Following the vanes, the three beams are recombined to the aperture in a common beam by another set of three dichroic mirrors. Red is reflected into it by mirror No. 4, green by a cyan-reflecting, red-transmitting mirror (No. 5) and blue by the blue-reflecting, yellow-transmitting mirror No. 6. Some cylindrical elements shape the final beam to the size of the aperture.

For fade and lap-dissolve effects a fader shutter is provided in the common beam between the lamp and the first dichroic beam splitter.

Light-Control Devices

The Tape

Automatic printing requires a device that tells the printer what to do and when to do it. Equipment of this kind is common in many systems of automatic control. One well-known, reliable system, the Friden Commercial Control Tape System, has been adapted to the printer. It provides an 8-hole paper tape (Fig. 2), and the device is able to read 20 infor-

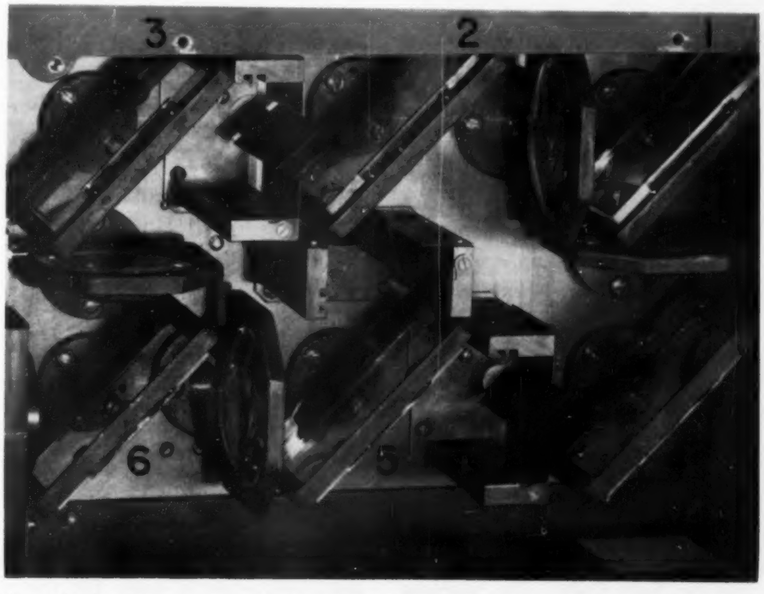


Fig. 1. Light control system, showing vanes, dichroic mirrors and filter holders. Lower right corner: target for lamp adjustment.

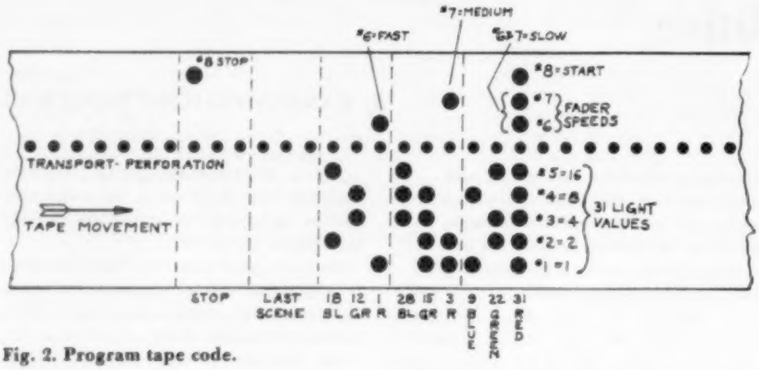


Fig. 2. Program tape code.

mation bits/sec. Five holes on one side of the transport perforation determine the color intensity in a code corresponding to a progressive power of 2:

First hole, $2^0 = 1$
Second hole, $2^1 = 2$
Third hole, $2^2 = 4$
Fourth hole, $2^3 = 8$
Fifth hole, $2^4 = 16$

Any figure between 1 and 31 can be obtained by one of these values or by an additive combination of them. These five holes on the tape provide the light-control device with 31 different signals, which will be translated into 31 light values.

One row of tape holes is needed for each color. The complete information for one color balance therefore consists of three rows of holes.

The three holes on the other side of the transport perforation are used for fader as well as for start and stop signals. Holes No. 6 and 7 — separately or combined — determine one of three fader speeds, and No. 8 hole is provided for starting and stopping the printer. These three holes are punched with the first row of the three-row cycle. The sequence of the cycle is red-green-blue, but laboratories that are accustomed to a yellow-magenta-cyan cycle in substractive printing may use the complementary blue-green-red cycle.

The Perforator

To produce the tape in the easiest and most error-free way a Commercial Control Tape Punch device has been extended by additional features (Fig. 3): Three rows of 10 pushbuttons operate the light values No. 1 to No. 30; No. 31 is in the fourth row. This lowest row also contains the pushbuttons for advancing the tape (TA) before and after punching, for starting (ST) and stopping the printer (E for End), for the three fader speeds (SF for Slow Fade, MF for Medium Fade and FF for Fast Fade) and for fades without a simultaneous light change (FO for Fade Only). The punching cycle in color begins with red. If the perforator has been stopped at green or blue in a previous operation, it can be brought back to red by pushbutton "O" (O for Order). Pushbutton "BW" (for Black-and-White) switches the perforator from a three-row-cycle color operation to a one-row black-and-white operation. In this position a tape can be punched to be used on the Automatic Shutter Control for D and J printers.

Three color-indicator lights and a scene counter show which color of which scene is to be punched next. The counter counts every third punch on color. On black-and-white every single punch is counted and the indicator lights are off. For fades without a light change at the same time, one or two fade holes are punched and the tape automatically advances two more blank steps to complete the full three-step color cycle. At the end, three blank steps must be provided to clear information in memory while the last scene is being printed. To stop the printer, another three-step cycle is used with two blank steps and the No. 8 hole at the end. Thus five blank steps are between the last color-information row and the end hole. At black-and-white there is only one blank step in between.

All these features are performed automatically. Safety features are also provided, such as: No punching is possible without pressing the start button first. No start and no fade cycle is possible without the red light being "on," indicating a start in the proper sequence of operation.

The Color Memory Device

Once the tape is perforated, it is fed into the reader (Fig. 4). In the darkness of a color printing room it cannot be expected that the operator will be able to thread the tape so that the start hole comes exactly at the reading point. Therefore means have been provided enabling the tape to be placed anywhere in the reader with the start hole on the left of the reading area.

When the AUTO (for Automatic) button is pressed, the tape advances to the start hole, where it stops. The reader starts the printer drive motor and reads the three lines of information on the first cycle. These three sets of signals are distributed to the corresponding three color banks. In these devices the 5-digit code signals are translated into one of 31 single signals to determine the light values. In addition to the five relays, which implement the decoding, there is a transfer switch that shifts the whole tape information for this color bank up, or down, three steps. This provides for corrections due to small changes in emulsion color balance. Five lamps on each color bank indicate the incoming code signal for service checks.

The 31 decoded signals, their number increased to 37 by the six transfer-switch trimming steps, are connected to corresponding contacts of a stepping switch as a contact to ground. The stepping switch rotates by means of a feedback circuit until it finds a grounded contact, and stops at that position. A spiral cam is mounted on the stepping-switch shaft. The cam follower, riding on the cam, moves the cup around the vane-operating solenoid. This position is kept in memory until a cue signal from the film energizes this solenoid, which then transfers this information into the corresponding vane position. This done, the reader reads the next information cycle, the color banks decode it, and the stepping switches put it again in memory. The cam and the vane solenoid are highly precise parts. They finally determine the degree of precision and repeatability of the light values. The printing light values are spaced from each other in logarithmic steps of the light intensity E. From one light to the next one there is a step of $\log E = 0.025$. The total range of light that can be controlled by the tape amounts to 0.75, and including the six trimmer steps, to 0.90.

The Color Light Change Signal

Once the first color light value is stored in memory, the device is ready for a cue signal to transfer the information to the vanes at the right instant. This cue can be given by a short pulse from a notch in the negative or from an aluminum patch applied to the negative. The notch operates a switch by physical contact, whereas the sensing probe, taking a pulse from the patch, does not touch the film. The patch, which may be applied on either side of the film, disturbs the feedback circuit of a radio-frequency oscillator by eddy currents and stops it from oscillating. This effect generates a pulse, which through a relay is transferred to the cue amplifier, energizing the vane solenoids and simultaneously starting the next reader cycle.

The Fader

For special effects a fade-in, fade-out or lap-dissolve can be performed. The fader device can be operated at three different speeds: 16 – 32 – 48 frames (1 –

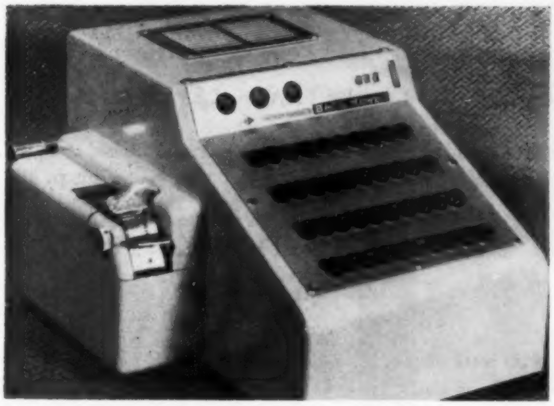


Fig. 3. Program tape perforator.

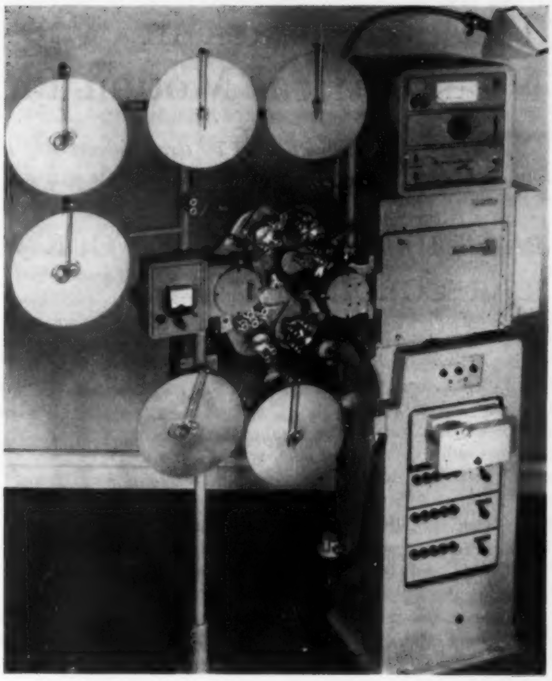


Fig. 4. Combined picture and sound printer.

2 – 3 ft) at 35mm, 20 – 36 – 48 frames at 16mm. The signal for a fade at any of the three speeds is held in memory and released with or without a light change by the notch or patch mentioned above.

Other Design Features and Accessories

The film-movement part of the printer is quite similar to the design approved for decades on D and J printers. As a new feature, a roller gate replaces the fixed gate shoe for better contact and resolution. The roller is so adjusted that it barely touches the film and it can float in its bearings to maintain uniform contact pressure over the width of the film.

An air-pressure device provides a constant stream of air to the film from inside the aperture. This prevents dust from sticking to the edge of the aperture, thereby causing streaks on the print. The air is cleaned of moisture and dust particles by an air filter. A manual trigger enables the operator to increase the air pressure through the aperture for cleaning before and after printing.

A synchronous motor drives the printer at 150 ft/min and a special dynamic braking device replaces the mechanical brake used on D and J printers to prevent the printer from coasting after a stop. Torque motors drive the take-up cores.

The printer lamp current is controlled by a large rheostat, the range of which can be enlarged by switching in an additional fixed resistor. Among other control devices are a large suppressed-zero-scale ammeter for printer lamp current reading, a resettable footage counter, indicator lamps to show whether the fader is open or closed, and an hour meter for determining the actual operating time of the printer.

Three large pushbuttons in the printer base include the main start and stop switches. The left one, marked AUTO, is operated to begin the complete automatic printer operation from tape start to automatic stop. The middle button, which stops the printer if any operational condition makes it necessary, can be termed a "panic button." The right button, marked TEST is provided to check the printer without tape. For safety purposes, this switch does not work while tape is in the reader, and the AUTO button does not operate without tape in the reader. The two smaller buttons are used for manual cue and fade operation, primarily for testing purposes.

Additional accessories include an edge number printing device, and a Zero Light Douser which makes A and B printing possible on long uncut scenes. This device cuts the printing light entirely at a cue and reopens the aperture at the next cue. This avoids the necessity of cutting a negative exactly at a given point. The douser is automatically controlled by one of the holes in the Program Tape.

Sound Printing

A separate sound printer head can be attached to the additive printer to save time by printing picture and sound from two negatives in a single operation. Two apertures are provided in the 35mm sound printer for head and tail printing. The printing lamp voltages are stabilized by regulating transformers.

The first Bell & Howell Additive Color Printers and Soundheads are in successful operation in several laboratories. It is a pleasure to mention, in grateful appreciation, the open-minded cooperation and the valuable suggestions from laboratory engineers during the initial operation and run-in period of the first printers.

The Soundtrack in Nontheatrical Motion Pictures

By FRANK LEWIN

The functions of the three components of the soundtrack—voice, music, sound effects—were delineated in Part I. Part II considered in detail the editing of the components. Parts III and IV follow. **See Notes on p. 488.**

PART III – PREPARING WORK PRINT AND SOUND TRACKS FOR RE-RECORDING

Conditions are outlined which govern the division of the work picture into reels, arising from the difference between editor's and printer's sync and its effect on the joining of sound across reel breaks. The physical condition of the work print for use in sound editing and at the re-recording is described. Details are given regarding the treatment of opticals in the soundtrack, sync markings, leaders, and the shipping and storing of tracks.

By the time the work print of the film is ready for music and effects it must be assumed that it has been edited to its exact length. Only in unusual cases is it justified to make changes affecting the film's length after work on the editing of music and effects has started. Physically cutting the work print is a simple operation: a snip of the scissors and a splice — the change is made; when narration has been edited, one sound track becomes involved in the picture cut and must be resynchronized. When, however, music and effects tracks have been edited as well, one cut in the picture means the resplicing, and keeping in sync, of from one to seven additional tracks (or more). Furthermore, all logs and cue sheets indicating what takes place on these tracks must be altered with each change. The chances of emerging from the process without some mixup are slim indeed, especially when time presses. It is preferable to delay the start of editing the sound tracks until the picture has its final shape and length.

Division of Work Picture Into Reels

The completed work print of the film reaches the sound editor on one or more reels. With 35mm films the length of the reel is most commonly 975 ft or less, for that is the maximum length of usable negative out of a standard roll of 1000 ft to which the mixed soundtrack can be transferred. Occasionally a reel of 35mm film may exceed 1000 ft; in such a case an end sync mark — visible on the work print and audible on the track so that it will be visibly reproduced on the negative — is helpful. The mixed soundtrack in excess of 1000 ft will then be transferred to the beginning of a second roll of negative (generally so as to provide an overlap with the end of the first roll of negative). The second section of negative will be synchronized from the end mark, and the negative cutter splices the two parts together to form the complete soundtrack.

With 16mm films the restriction as to reel length is not dependent on the length of the negative stock (it comes in 1200-ft lengths, the equivalent of 3000 ft of 35mm). Theoretically a full 1200 ft (approximately 33 minutes) can be re-recorded at one swoop, but that is very rarely done in practice. Most sound is edited on 35mm magnetic film (and for optimum quality 35mm is mandatory) even though the picture work print is 16mm; this would mean that for a film up to 33 minutes in duration the tracks would be as long as 3000 ft. While most dubbers can accommodate oversize reels, assembling and handling these units create problems in the cutting room. More important, however, is the fact that in any but the simplest jobs it is difficult for the mixer to remain alert to the requirements of the mix for so long a period. Repeated rehearsing is as a rule necessary to balance successfully all the elements of the soundtrack for even a relatively short stretch of film. The chances of achieving a successful take are thus diminished the longer the section of film to be mixed in one go. Where it is known that few technical problems exist in the various tracks and the layout of the tracks is extremely simple, it may safely be ventured to mix fairly long sections of film at one time. In the case of an intricate array of tracks, however, the length of the reel must be kept to a reasonable norm (12 minutes or less).

The advantage of mixing fairly long reels lies mainly in preserving a certain feeling of continuity, both in screenings and at the mix. A minor plus point might be that it is sometimes faster, and therefore cheaper, to mix a smaller number of reels as stopping between rehearsals and rewinding time is minimized. However this consideration will often be nullified by the fact that more runthroughs are needed to obtain a good take.

The splitting of the work print into reels ought to be dictated by considerations in the soundtrack. The only restriction the image imposes is the fact that in 35mm films the break cannot occur where an optical effect merges one scene into the other, i.e. any optical except a fade; 16mm films, being printed in one continuous length up to 1200 ft, are subject to this restriction only if the prints are reduced from 35mm. Primary consideration must be given to the fact that when sound and picture are eventually printed, the sound for each given frame is printed ahead of the picture. The reason for this condition is that whereas the motion of the image through the gate at the point of projection must be intermittent, that of the sound over its reproducing mechanism must be continuous — consequently the two elements of reproduction must be located a certain distance apart (Fig. 1).

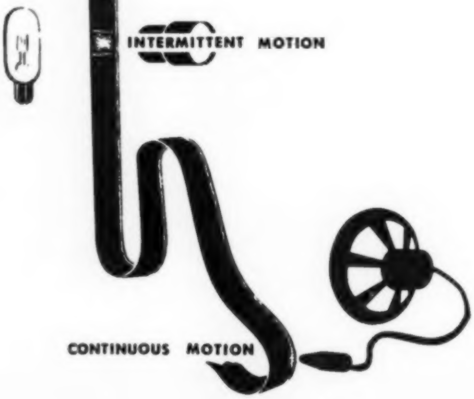


Figure 1

In the case of 35mm film this distance has been standardized to exactly 20 frames, with 16mm it is 26 frames (Fig. 2).

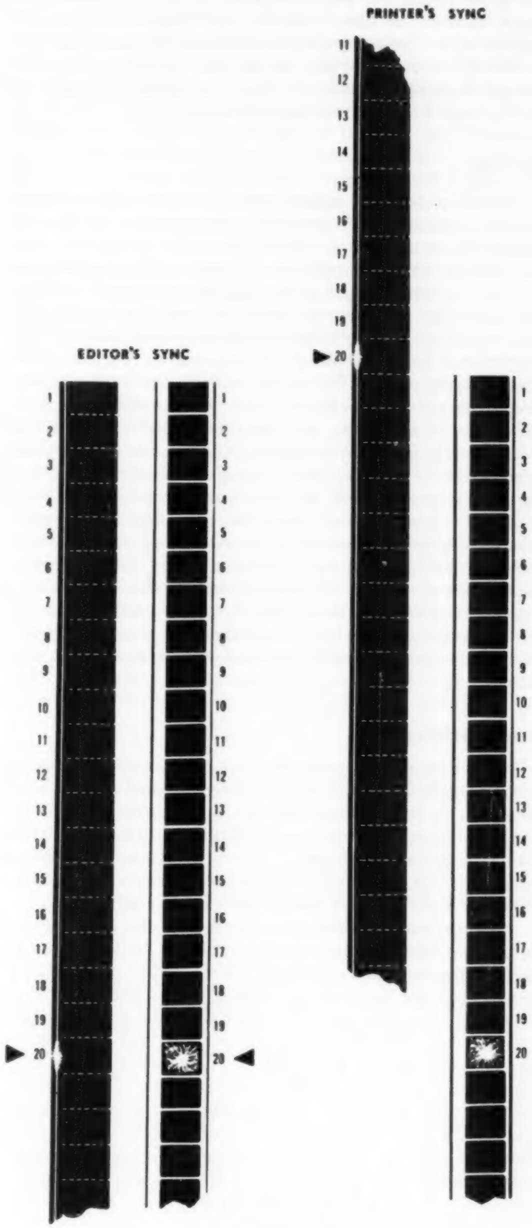


Figure 2

Before the negative of the soundtrack is wedded (printed together) to that of the image it is advanced the 20 frames necessary for 35mm, 26 frames for 16mm. This means that the first 20 (26) frames of Reel Two will in the final print appear physically next to the last few frames of Reel One. The only way this sound can be included on the track is to re-record it at the *end* of Reel One (Fig. 3).

From the above it will be plain that a physical splice occurs in the negative soundtrack between the 20th and 21st frame (26th and 27th frame in 16mm) of the first scene of Reel Two. Care must naturally be taken that no important sound (such as a word of the narration or music sensitive to interruption) is affected by this splice. It is best therefore not to start a reel on a cut which carries a well-defined sound within these first few frames. Continuous neutral sound effects lend themselves best to a joint of this kind as they can be spliced anywhere without being audibly affected. When such an effect is common to both scenes on either side of a reel break the sound may, as a matter of fact, be re-recorded with an overlap; when the negative is spliced together the superfluous sound may safely be snipped off the end of Reel One and the beginning of Reel Two.

When a specific sound, especially music, occurs across a reel joint in a picture which is to be printed in both 35mm and 16-mm, provision must be made to accommodate both the 20-frame and the 26-frame advance. One method consists of using two identical prints of the music, creating an overlap. The sound will then be joined as described above in the case of indeterminate sound effects in which the superfluous sound is removed as the negative is joined. Where this method is not practicable an alternate solution may be resorted to: re-record Reel One allowing the music to run 26 frames past the last frame; this means, of course, that the sound is laid into Reel Two so as to start 26 frames late. After Reel One has been successfully mixed, physically remove the last six frames out of the music track and splice them ahead of the start of music in Reel Two (thus creating only a 20-frame delay). The result in actual practice is to create the desired overlap: when joining the 35mm negative the *last* six frames of Reel *One* can be cut off (as they have been re-recorded at the beginning of Reel Two); when joining the 16mm negative the *first* six frames of Reel *Two* will be cut off.

One way of avoiding trouble at the juncture of two reels is to end the first reel with a scene whose picture fades out, and start the next reel on the following fade-in. The black between fades may be extended at will so as to include the advanced soundtrack. Any fade-out/fade-in in which the joint of sound to sound is thus treated, whether it occurs at the points reels are joined or at any other point in the film, may be readily cut in the final composite print should this become necessary — the cut can be made at that point between fades where the black of the film and the juncture of the sound coincide (Fig. 4).

It is easy to come to regard the reels into which a film is divided as units. They are, however, purely mechanical conveniences; care must be taken always to envisage them joined together in the final product without any interruption in time. Consequently the joining of two sounds straddling a reel break must be subject to all the aesthetic conditions that prevail with the juxtaposition of sequences anywhere else in the film; especial care must be exercised not to disturb the overall pace of the soundtrack. To avoid falling into the trap of considering the end of a reel as a sharp division in the film (where this is not actually the case) it is often advisable to make the break *in the middle* of a sequence whose length and pace has been adjudged satisfactory prior to separating the reels. In such a situation the break does not coincide with a transition in the soundtrack — which may be subject to experimenting during the mix — but will be clearly recognized for what it is: a purely mechanical interruption of which no one viewing the finished print should be in the least aware.

Condition of the Work Picture

To avoid delays at the re-recording session the physical condition of the work print must be such that no hitch can occur in the projection. This means that splices hold firm, sprocket holes are undamaged, tears repaired, and creases that might catch in the projector are smoothed out. When in the editing the print has been subjected to a great deal of wear, it is often advisable to have a dupe printed for the sound editor's use — the cheapest process which does not impair the recognizability of the image too seriously will do. Editing sound entails running a print back and forth repeatedly on the editing machine. If the print when thus used requires frequent repair, the danger exists that frames to which a sound effect is to be synchronized will have been discarded; the scene then must be

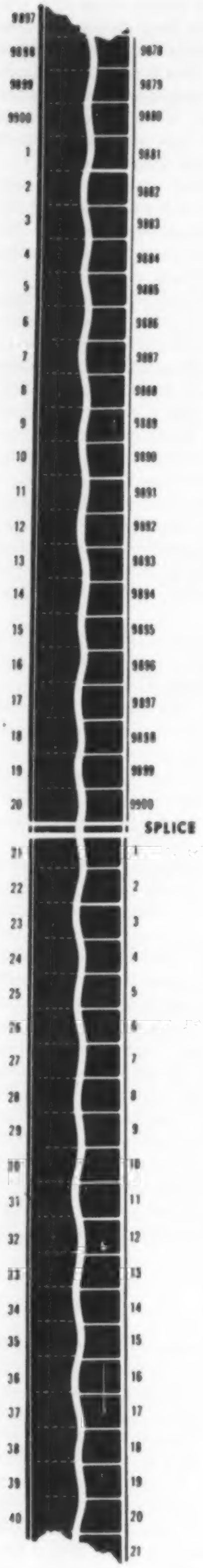


Figure 3

Figure 4

reprinted or the effect will be edited by guesswork. At least *once* before the music or sound effects editor buckles down to editing the details to a duplicate print, he ought to have seen a decent print of the film. It is especially important to anyone responsible for the composition or selecting of music to know the "feel" of a scene — an impression generally conveyed through lighting or color. A dupe will often obliterate all shadings and leave only the physical shapes.

Opticals

The sound editor — music or effects — is directly concerned with the opticals which connect or separate scenes. If at all possible the music and the effects should be edited to a print that contains whatever opticals will be in the film. At the least they must be clearly marked on the print the editor is working with, and they are indispensable to an accurate re-recording. It is not enough to write "diss." on the print and leave it to the sharp eyes of the sound editor to discern the writing as it speeds through his machine. The conventionally accepted markings for opticals should be cleanly drawn on the film, with great care given to indicating the exact length of the transition. From a purely technical standpoint a cut or fade is treated differently from a dissolve when editing sound effects (and to a large extent music as well). It is pity enough that in the course of editing the image optical transitions are frequently treated haphazardly and mechanically without testing their effectiveness or feasibility (many are not even screened until the answer print is viewed — and then the surprises are many, some quite unpleasant); to leave the audible transitions to chance as well merely compounds the injury and does not seem worthy of a production whose cost may be thousands or tens of thousands of dollars.

Sync Marking

It is assumed that when the work print reaches the sound editor it will have enough leader (clearly, cleanly and explicitly identified) to permit threading up (approximately 9 ft), and that it will have an unequivocally identifiable start mark whose distance from the first frame of picture is at least 12 ft (35mm footage). If this is not so, getting these chores done constitutes a prerequisite to doing any work at all on the soundtrack.

At some point between start mark and the first frame of picture (or sound) a sync mark should be indicated on the leader of the work print, preferably scratched or punched in — grease pencil markings can get rubbed off; an audible mark on the mixed track (reproduced visibly once the track has been transferred to negative) must correspond to this sync mark so that negative picture and track can eventually be lined up. Commonly this sync mark will occur 3 ft (35mm footage) before the first frame of picture; at any rate it must be far enough down in the leader so that projector and dubbers will have attained full speed by the time the mark goes through. It does not matter greatly into which of the tracks the audible "bloop" (one frame of any loud tone will do) is cut, just so long as the mixer is advised which one it is. Where simultaneously with the mixed track a music and effects track is being recorded, i.e. all channels excepting those carrying the voice track(s) are being fed to a separate tape, it is advisable to place this bloop on one of the music or effects tracks, rather than on one of the voice tracks. The bloop then reproduces on both mixed tapes.

Leaders

The individual tracks must each carry their identity clearly visible at the head of the leader, including name of production, reel number, the designation under which the track will be listed on the mixer's cue sheet, and possibly a notation that this is the head of the reel. Sample:

PRODUCTION #510, "THE WILD OATS" — REEL 2 — EFFECTS A — HEAD

The start mark must be clearly indicated, preferably in indelible ink. In equipment such as magnetic dubbers the film is in constant contact with the reproducing head; therefore grease pencil or other marking media which readily come off should not be used on the sound area of the magnetic film as they can easily clog the reproducing mechanism and produce faulty sound reproduction. This caution applies to any marking over the entire length of the track, naturally. In this connection a strong word may be inserted against the practice of fastening the end of the track to its reel with masking tape. The damage the adhesive causes if it becomes wedged in the reproducing head can be a source of considerable annoyance at the mix. The apertures of slots in reels are large enough to accommodate any strip of film; why not put them to the use for which they were designed: threading up the film. (Projectionists will confirm that the same conditions apply to picture reels.)

At the end of a reel of sound there must be sufficient leader (10 ft or more) to keep the track firmly in the dubber until all sound has passed the reproducing head; short leader is a frequent cause of wow at the end of a reel and can effectively nullify at the last moment an otherwise flawless take. The very end of the leader should be as explicitly marked as the start of the track, with the addition of the word "TAIL" or "END." With clearly marked leaders a lot of guesswork can be eliminated when the tracks need to be handled before, during, and after the mix.

Theoretically anything having sprocket holes in the proper position may be used as leader for a magnetic sound track. In practice the cheapest stock to be found is waste picture footage. Very great caution must be used in making certain that the emulsion side of the film used as leader never comes into contact with the head of a sound-reproducing mechanism. This means that whereas magnetic film runs through the dubber with *emulsion* toward the head, the leader must always pass with its *base* over the head. Disregarding this rule will result in the emulsion getting scraped off by being in physical contact with the reproducing head, thus blocking the gap which is instrumental in reproducing the sound. When a normally clean track sounds in the studio as if its high frequencies have been cut off, the cause will generally be some length of leader which was spliced in upside down.

Shipping and Storing Tracks

Before a track is shipped to the mixing studio it ought to be wiped free from dirt and other foreign matter adhering to it.

Each track should be provided with a clean can in which it is stored and transported. The outside of the can must have a marking identical to that of the leader at the head of the track which it contains. Tracks so enclosed are protected from dirt and dust; they may also be easily stacked and handled in transit. Anyone who has had to suffer from the effects of bent metal reels or chipped plastic ones (faulty tracking on a dubber, tearing of film through uncontrollable tension, trouble during rewinding) — generally resulting from a stack of unprotected reels that were dropped at some time or otherwise mishandled — can testify to the value of using cans. Loops should be treated with equal care as to marking and storing.

Before all the material is shipped to a screening or mixing studio it is advisable to make out an inventory of all tracks, loops and picture work prints. This is of especial value when the number of units is large. It is helpful to the attendant in the dubbing room to receive a copy of this list — a lot of telephoning back and forth between mixing studio and dubbing room can thus be avoided. Checking the units against this list before they are shipped will also guard against the danger of leaving part of the material behind in the cutting room.

PART IV – RE-RECORDING

The physical make-up of the sound tracks is described. The re-recording engineer's functions are outlined, together with a discussion of the cue sheet which provides him with the information necessary for mixing the tracks. Some points regarding etiquette at the re-recording session are suggested.

IT MUST again be emphasized that the effectiveness of the final soundtrack is largely governed by how intelligently the component tracks are laid out for re-recording. The re-recording engineer (mixer) generally has not heard voice, music and effects nor seen the picture until he makes his first runthrough; he is therefore acquainting himself with his material as he goes along. Anything that helps him to minimize his technical problems will free his time and attention for concentrating on aesthetic points. This is especially true as mixing time is frequently quite limited. When the mixer must devote most of his time to straightening out technical problems, there comes a point at which the customer begins to watch the clock and cares little about having the subtler touches of the track carried into reality in his rush to get the job done any which way.

Physical Make-up of Sound Tracks

One way of helping to expedite a mix is to avoid leaving extraneous sounds on the individual tracks. The best way to prevent a sound from being heard is not to put it into the track in the first place. Ideally each track ought to contain musical sections or sound effects which are clean at either end. This is especially true of the start of the sound. The track should be cut as close to the modulation as is possible without chopping off soft attacks. In this way the mixer may leave any channel open without having to worry about unwanted noises entering ahead of music or sound effects. A bonus with this procedure consists of being able to have a rough runthrough with all channels left open and thus get a fair idea of what the overall soundtrack is like. It is evident that this also facilitates preliminary screenings prior to the actual re-recording session. Another advantage to be derived from starting sounds clean and tight before modulation: it is possible to perform emergency operations on the synchronizer during a mix without having to run the track through a sound reader or editing machine — any piece starts clean (even the B of a track laid out on A and B), ergo it may be moved mechanically if it is needed in another spot (or different reel) and pinpointed to the frame.

Tracks must be laid out so that an operation for which the mixer needs two hands does not coincide with any other operation that requires his manual attention at that precise moment, voice track(s) included. In practice this means that a crossfade, for example, cannot coincide with a fade-in, or another crossfade, at the same instant. If at the time a crossfade takes place another track enters automatically, the editor should make sure that the track really does enter clean. When, for instance, a traffic effect is preset at the same time a musical crossfade takes place, it must be ascertained beforehand that the traffic does not chip in with an auto horn that is clipped at its start. In this connection it may be mentioned that not all picture opticals call necessarily for crossfades (in the case of dissolves or wipes) or fade-ins (with optical fade-out, fade-in) in the track. A quiet background sound which is preset to enter in the middle or slightly ahead of the center of an optical dissolve works as

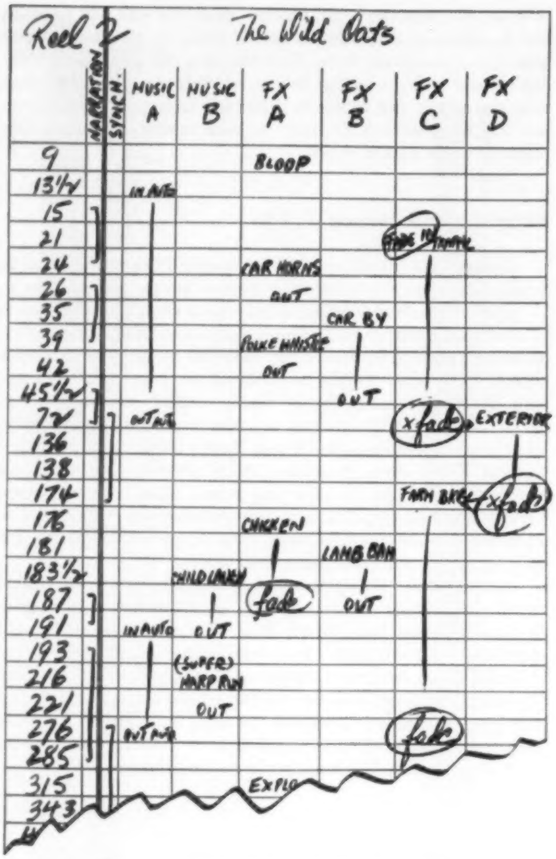


Fig. 5. Excerpt from sample cue sheet.

well as one that is faded in at this point. The same goes, in a more restricted way, for exits. It is sometimes good practice to have the fade-in or fade-out built into the track by having it transferred that way before the sound is cut into the track. It is not advisable, however, to abuse this method. Unless real problems exist at these juncture points, it is better to let the mixer have control over fades: until all tracks are heard simultaneously it is not always obvious at which point a faded in sound is to achieve full level in order to be most effective.

It is impossible to expect a mixer to pinpoint a fade-in to the frame, unless the picture is marked or punched to give him a visible cue. In the case of a complicated assortment of tracks even visible cues do little good as the mixer will have to watch the footage counter more than he will be able to watch the picture. This is especially true in studios where the footage counter is located on the control panel rather than projected near the screen. Consequently, if a sound is to start precisely on cue with the picture it should be laid into the track so that it can be preset to hit clean. This applies with even greater force where one sound joins another on cue. The two sounds should never be cut together on one track if any mechanical change has to be effected involving either sound. When placed on two tracks, the outgoing sound need not necessarily be cut at the point where the incoming one starts — it may be faded out when the latter hits. The incoming sound, however, must be preset — it cannot be faded in if it is to hit on cue.

It is futile to expect the mixer to do the work that should have been done at the time the track was cut: he cannot, for instance, be expected to fade into a piece of music precisely on a beat. He also cannot be expected to provide a piece of music with a good beginning, or end, when the piece does not lend itself to this treatment. It is likewise beyond the call of a mixer's duty to salvage bad cuts. If a cut involves violent level changes; if it joins two pieces (or sound effects) equalized differently and out of proportion to each other; if it tries to connect wildly divergent orchestrations; and especially if it is musically unsatisfying — it had better not be attempted in the first place. Separating the joining pieces onto two tracks will often do wonders in smoothing out technical problems. If, for some reason (sometimes a good one), this is not practical, the problem may be circumvented by superimposing at the problem point another sound (on another track) which will mask the defective cut, as described in Part II in the section devoted to superimpositions.

In all cases of covered up cuts, however, it is well to remember that they are crutches only. When used too frequently the devices will become obvious. A good cut can't be beat, that's about it.

Cue Sheet

Most of the information necessary for acquainting himself with the tracks before him is conveyed to the mixer from the cue sheet. An excerpt from a sample cue sheet is reproduced in Fig. 5.

The maxim of avoiding the unnecessary applies to the cue sheet as it does to the individual sound tracks. What the mixer needs to know is

(a) the footage at which a sound starts;
(b) what the sound is;
(c) how the sound starts;
(d) how long the sound runs;
(e) the footage at which the sound is to end; and
(f) how the sound ends.

(a) The Footage at Which a Sound Starts

Films are most commonly mixed according to 35mm footages, whether the work print is 16mm or 35mm. Consequently the footages listed on the cue sheet must be in 35mm. It is over-optimistic to expect the mixer to react to footages smaller than half a foot; to expect him to hit frames is, of course, impractical. Figures rounded off to the nearest foot are, therefore, adequate. It is quite helpful to write the footages so that the figures are legible. Cue sheets that furnish figures and information unclear or inexact lead to much unnecessary conversation at mixes.

It may be found of advantage to divide the cue sheet into columns, each representing one of the tracks running synchronously. If at any given footage more than one track enters simultaneously, it may be advisable to write down the footage only once, say all the way over on the lefthand side of the sheet, and on the same line, horizontally, list the activity in the separate tracks. Mixers' preferences in the making up of cue sheets vary and it may be well to find out beforehand how the mixer would like to receive his information, especially in the case of a complicated job.

At this stage it may be appropriate to comment on the best point, in the process of setting up a cue sheet, at which the 16mm footage should be converted to 35mm. It is of advantage to let this conversion be the last step before making up a final cue sheet for the mixer. As the work print is in 16mm, any changes, corrections or questions that come up will generally have to be referred back to the picture. If the conversion to 35mm has been done at an earlier stage (that applies also to narration and dialogue cues) the figures may have to be changed back to 16-mm footages. As any step in the conversion not only consumes time but may lead to errors as well, the opportunities for confusion are thus greatly encouraged. It is advisable that the editor have his original 16mm footages at the re-recording for reference so that last-minute adjustments can be made in picture and track with the least delay possible.

(b) Identification of the Sound

Any sound entering should be clearly identified. In the case of a narration track it is recommended to let the mixer know

of changes within the voice track which may create problems (change of narrator, differences in equalization or level). Many of these spots the mixer will, of course, note by himself after a runthrough, and some mixers may prefer to find out for themselves rather than get possibly imprecise comments beforehand. In general it may be assumed, however, that the more useful information can be given to the mixer the better.

It is of little value to describe the character of the music when a cue enters, unless that has some bearing on its mode of entering (starting a very loud cue softly or vice versa). In the case of sound effects it is of importance, on the other hand, to identify each effect, especially when several occur simultaneously, so that the mixer can sort out the ones that are to predominate. When similar effects run parallel on two or more tracks it is of value to show in what respects the sounds differ: whether they are staggered; whether they complement each other and in which way they do this; whether they are included so that they can be tried separately under the optimum conditions available at the studio to find which one is most effective with the picture; or maybe because the editor wasn't sure and figured that two are better than one — they seldom are.

(c) How the Sound Starts

It may generally be assumed that unless specific instructions are given, a cue enters clean — the track having been preset previous to its entry. If the cue is to be faded in or arrived at via a crossfade from another track, this fact should be clearly stated on the cue sheet. The decision as to how a track is to start should be made before the mix — experimenting during the mix can be quite frustrating, especially for the mixer who, if he does not get the information from the sheet, has to try to get it verbally from the editor or whoever else has a say at the mix (frequently a surprisingly great number of rarely well informed persons).

(d) How Long the Sound Runs

Once a cue has entered, some visible way of indicating its duration is helpful. A simple straight line, terminating at the footage at which the cue ends, will do to denote a cue's length. In this connection it may be apropos to mention the frequent evidences of artistic talent encountered on cue sheets. They should be universally discouraged. Anything that does not convey specific information impedes the mixer's attempt to fathom the mysteries of the sound tracks entrusted to his care. Colored inks or pencils; doodles; aimless arrows; single or multiple underscores; meaningless circles — they all take time to prepare as well as to decipher. A clean cue sheet written in pencil has the advantage over an inked one in that changes can be made by simple erasure.

To go back further in the process: it is entirely possible to make out a cue sheet at the time the sound is cut by the editor which will serve all along the line until the mixer receives it. All the essential information can generally be put down at the time the track is laid out, including voice cues — the less copying out from rough sheets, the less typewriting, the less dressing up, the fewer chances for errors.

In the case of narration cues, how short a break in the track is it worth while to take into account? Generally, any hole less than three feet in duration (35mm footage) is not effectively vitalized by bringing up music or continuous sound effects. Exceptions to this abound, naturally, when a soundtrack is treated in great detail and noticeable changes in music occur or interesting sound effects are to be brought to the fore in relatively small interstices in the voice track. In these cases it is well to advise the mixer that a sound on one of the tracks hits in a clear spot, even if the breathing space is not more than 12 frames or so.

(e) Footage at Which the Sound Is to End

It is important to give a precise footage at which the sound is to end, insofar as this can be determined beforehand (it generally can be — quite accurately). It is often helpful to denote on the cue sheet how long the sound continues on the track past the point where it is to be terminated mechanically. In the case of crossfades this gives the mixer an indication as to the latitude he has for varying the exact point of the sounds' changeover. Listing the "out" footage also tells him how much clearance the track has before a following cue enters — of especial importance when the next cue is to be preset.

(f) How Does the Track End?

Any track that ends clean, i.e. without a mechanical operation on the mixer's part, should be thus identified. This may be done by marking it "out auto(matically)" or any other clear indication such as a definite conclusion of the line (or other symbol) used for showing the duration of the sound. If the track is to be faded out, or crossfaded to another track, this should be plainly indicated. The question arises as to where precisely a fade-out becomes final or at what point a crossfade becomes established, and how should it be indicated in terms of footage? The practice of trying to indicate on the cue sheet the point at which the fade is to start mechanically can be justified if at the same time a footage is also given at which the fade becomes final and the sound is to be out altogether. It is probably simpler to list only one footage, and make that one stand for the cessation of sound. How the mixer gets there and how early he starts to fade would then be dictated by circumstances either on the screen or in the track itself. In the case of a crossfade, it is likewise difficult to give a precise instruction. If the footage listed stands for the center of the crossfade, the exact execution may then be left to the discretion of the mixer — it is anyhow often a question of "feel" and cannot be pinned down exactly.

Re-recording Session (Mix)

A mixer is a human being — a fact often overlooked by people at the re-recording session. The strain to which he is subjected is frequently greater than it seems advisable to burden a human being with. While this dissertation has attempted to confine itself to technical information, the human element in a mix is so closely related to what the finished print sounds like that it should not be neglected.

It is patently unfair to expect the first runthrough of a reel to come up to the expectations of director, editors and others who have spent the preceding weeks or months in intimate contact with their creation. They know — or think they know — what the track is supposed to do and should sound like — the mixer has to feel his way and must find out through trial and error. The less said after the first runthrough by all concerned, except the mixer asking questions, the better. He is assimilating and trying to integrate a complex assemblage of sounds; he hears many things which he would like to balance out or correct, if he is given enough time; he appreciates a few moments to make notes, repatch connections, and generally sort out what is important on the sound tracks from what is secondary.

The re-recording engineer has a further function — often felt, seldom expressed. He must perform a role similar to that of a host at a social gathering, and depending on how many clients and clients' clients, and clients' clients' representatives there are assembled in the studio, this role is correspondingly onerous — all this on top of doing the technical job required of him.

Once the question-and-answer period of the mix really gets under way, the mixer is constantly called upon to render judgments — often on subjects irrelevant to his work: "Does the film hold up?"; "How do you like the cutting (directing, casting, color, props, focus . . . integrity, showmanship, message) of the film?"; "Why is the studio so hot (cold)?"; "How much longer will it take us?" Getting all the sounds balanced is a delicate operation, calling for taste, experience, nimbleness of hand and mind, a sense of timing, and physical stamina. Whatever is helpful ought to be discussed; whatever is perti-

nent needs to be settled; whatever problems occur must be solved. Anything tending to be unpertinent and impertinent has no place at a mix; and a special anathema should be reserved for unnecessary telephone calls, made or received.

How to prevent waste at a mix and avoid the unproductive? Primarily, it is important to keep perspective. The film in the process of being mixed has progressed through several stages from its embryonic form in the script. It is futile to make the soundtrack conform to an idea implicit in an earlier stage of the film if, in the meantine, the thought has been watered down or has evaporated in the shooting or in the cutting. A scene that is weak will only rarely be improved by playing the music louder, especially if the narrator is going an average of 85 ft out of 90. A sound effect that is not satisfactorily established by the visual will not lend credibility to an improbable scene. A narrator whose delivery lacks conviction cannot be infused with energy by a boost in level or a change of equalization. A music or sound-effects track that is improperly laid out cannot be made to sound graceful and lifelike; a musical recording that sounds thin is only minutely improved by the liberal use of echo; an effect that sounds poor to start with can only partially be rejuvenated electronically — all these things the mixer knows before he even starts in, and the editor (director, producer) should know before he gets to the mix. Clients, when they are aware of what is going on, should be advised tactfully of derogatory conditions, and under no circumstances should they be led in at 2:15, for a mix that started at 2:00, with the expectation of hearing something faithfully representing what the finished film will sound like.

There is no question that the more runthroughs a mixer is able to perform in the time allotted to him, the better he will be able to realize the potential inherent in the tracks. There is one sure recipe for getting the most out of a re-recording: being thoroughly prepared. As suggested above, at least one interlock screening should precede any fairly complex re-recording session. Enough time must be allowed between this screening and the date of the mix to enable the sound editor to perform changes where necessary. The sound editor should come to the mix having listened to *every frame* of the sound tracks that he has cut in. The mixer gets many surprises in the course of his first runthrough; when the surprise is shared by the editor, the re-recording session is likely to turn into a quite lengthy affair.

Summation

The possibilities of the soundtrack for a film are virtually limitless. It is true that a certain amount of time is necessary to create an effective soundtrack — this must be included in the production schedule from the very beginning; a good result can be achieved only with skilled technicians and experienced artists — provisions for their employment must be considered in the budget. The realization of all of a track's potential necessitates using first-class studios and equipment — that takes a tight rein on the temptation to save pennies. Above all, a truly effective soundtrack requires imagination and the patience to experiment — conditions which are frequently discouraged by the climate in which business films are sold and produced. The rewards of a soundtrack, however, which in addition to conveying a message enhances the picture and is viable in its own right are personal as well as practical: the film will wind up as a genuinely creative *sound* motion picture and the audience will respond to it.

Note: The term "soundtrack" refers either to the sound of a motion picture in general, or to the mixed track physically reproduced on the print. The term "sound track" refers to the individual track (*Voice*, *Music* or *Effects Track*) as described in editing and re-recording procedures.

Part I appeared in the March 1959 Journal. *Part II appeared in the June 1959* Journal. *The entire paper is now available as a heavy covered reprint at the cost of $1.00 from the Society headquarters.*

Presented on October 24, 1958, at the Society's Convention at Detroit by Frank Lewin, Filmsounds, Inc., 128 East 41 St., New York 17, N.Y. This paper was received on August 4, 1958. *Edit. Note:* Publication of this tutorial paper is a result of the Society's policy to present from time to time pertinent subject matter which is not otherwise currently available.

motion-picture standards

Published here is a new American Standard, PH22.114–1959, 16mm Azimuth Test Film, Magnetic Type, which was approved by the American Standards Association on April 17, 1959.

Since its trial publication in the April 1958 Journal, the standard has been changed as follows: rewording of paragraph 2.1, inclusion of paragraph 2.5, change in diagram and addition of table of dimensions.

A test film produced in accordance with these specifications is available from Society Headquarters.—*J. Howard Schumacher*, Staff Engineer.

American Standard

16mm Azimuth Test Film, Magnetic Type

Reg. U.S. Pat. Off.

PH22.114-1959

*UDC 778.5:771.531.551.2

1. Scope

1.1 This standard specifies a test film with full-width magnetic coating having a magnetic sound record to be used for aligning the azimuth of magnetic heads on 16mm magnetic recording and reproducing equipment.

2. Test Film

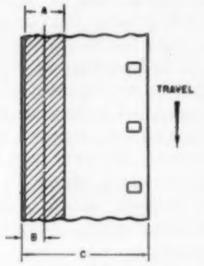
2.1 The test film shall have an original sound record having a wave shape that is approximately sinusoidal. The frequency of the sound record shall be approximately 7000 cps when the film travel rate is 24 perforations per second (approximately 36 ft per minute).

2.2 The sound record shall have correct azimuth within ± 3 minutes of arc.

2.3 The recording shall be made at 100 percent modulation level with a tolerance of + 0 — 2 db 100 percent modulation is defined as the recording head current at which 3 percent total harmonic distortion occurs at a signal frequency of 1000 cps.

2.4 The locations and dimensions of the sound record as shown in the diagram and table shall be in accordance with American Standard 200-Mil Magnetic Sound Record on 16mm Film Base Perforated One Edge, PH22.97-1956, or the latest revision thereof approved by the American Standards Association, Incorporated.

2.5 With the direction of travel as shown in the diagram, the magnetic coating is on the upper side of the film base.



Dimension	Inches	Millimeters
A	0.200 ± 0.002	5.08 ± 0.05
B	0.103 ± 0.002	2.62 ± 0.05
C	0.630 nom	16 nom

3. Film Stock

3.1 The film stock used shall be of the low-shrinkage safety type, cut and perforated in accordance with American Standard Dimensions for 16mm Film, Perforated One Edge, PH22.12-1953, or the latest revision thereof approved by the American Standards Association, Incorporated.

4. Length of Film

4.1 The film shall be supplied in 100-ft lengths.

5. Identification

5.1 The film shall have identification markings at both ends.

APPENDIX

(This Appendix is not a part of American Standard 16mm Azimuth Test Film, Magnetic Type, PH22.114—1959, but is included to facilitate its use.)

Fluctuations in signal level may seriously impair the ease and precision of setting an azimuth adjustment. It is recommended that the signal level when reproduced on high quality equipment and measured with a VU meter be held to a tolerance of ± 0.5 db through any 100-ft length of film. Exception may be made for occasional rapid level fluctuations such as may be caused by "drop-outs."

NOTE: A test film in accordance with this standard is available from the Society of Motion Picture and Television Engineers.

Approved April 17, 1959, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Printed in U.S.A.
ASA%M759/35

SMPTE Test Films

Test films planned by the Society's technical committees and produced under the Society's exact supervision are available from the headquarters office at 55 West 42 St., New York 36. Catalogs containing brief descriptions of each film are obtainable on request.

These films are used by manufacturers for testing the performance of new equipment, by television station technicians for lining up and adjusting film pickup systems, by maintenance men for "in service" maintenance of projectors and sound equipment, and by dealers for testing and demonstration equipment.

Films are available in the following categories.

- Television — Picture Only, Color or Black-and-White
- CinemaScope
- Visual 35mm — Picture Only
- Magnetic — 16mm Sound Only
- Picture and Sound — 16mm
- Picture Only — 16mm
- Glass Slide — 16mm

The SMPTE, The Army, Missiles and Space Vehicles

By Major General J. B. MEDARIS

(From the introduction by SMPTE President Norwood Simmons at the special session on instrumentation and high-speed photography, Miami Beach Convention, May 4, 1959: Our speaker, Major General John Bruce Medaris, is the Commanding General of the Army's Ordnance Missile Command. He directs all army ordnance programs in the rocket, guided and ballistic missiles, and outer space fields. He has seen combat in two World Wars, as an enlisted man and as a commanding officer. After World War II, he held various Army Ordnance posts and in November 1955 he was made Commanding General of the Army Ballistic Missile Agency, with responsibility for development and production of the Jupiter IRBM Missile System and further development of the Redstone Ballistic Missile System. In addition to these assignments, which he managed to successful completion, he was responsible for the launching of the earth satellite, Explorer I, on January 31, 1958. He assumed his present command, March 31, 1958. The command includes the Army Ballistic Missile Agency, the Army Rocket and Guided Missile Agency, Redstone Arsenal, and White Sands Missile Range.

Perhaps General Medaris's outstanding gift is his ability to manage complex research and development programs. He holds numerous decorations from the Army as well as from industry and the academic world. He has been awarded Honorary Degrees on five different occasions.)

I WELCOME this opportunity to discuss with the members of the Society of Motion Picture and Television Engineers the common interests you share with the Army in advanced work in your professional fields.

This evening I propose to refresh your memory with respect to some of the more notable contributions of military programs to the industries supported by your talents, particularly in the fields of television, optics and electronics. Then I will review briefly some of the areas in which we are now working. Finally I will discuss a few matters which are suggestive of the shining promise and the immense challenge of the Space Age.

The longer I spend in this exciting business of rocket and space developments, with all its inherent implications and continuous exploration of unknowns, the less I am inclined to admit that anything is impossible. The flashing progress of science and technology compels us to open our minds to the incredible, if we are to keep up with the possibilities, and have the courage to exploit new discoveries wisely and efficiently.

I want to make this flat statement at the outset — the interplay between military and civilian science and technology has become so intimate that the two must be considered virtually inseparable. . . . (For example) Military need influenced the miniaturization of television cameras, and the product permits today's television news teams to operate with minimum equipment at locations far removed from their base of operations. New programs in micromodule design, sponsored by the Army, will provide a new electronic dimension opening up glittering vistas for both military and civilian applications.

The field of meteorology has profited immensely from the Army's programs. . . . Out of military programs came radiosonde, and the Rawin device for tracking radiosonde transmitters. The radar tracking of storms 200 miles away, and the equipment to detect lightning activity at ranges up to 1500 miles, stemmed from military requirements. The modern electromechanical computer can be traced from the very early World War II use of relatively crude devices to further important work by the Army Ordnance Corps in ballistic research. We are pushing technology in all the related fields to the limit of our resources. We are continuously fighting the problem of engineering lead time, to transform promising scientific discoveries into useful hardware which can contribute to our needs for modern weapons and outer space vehicles.

Television a Useful Tool

Television is a highly useful tool in our business. . . . Of understanding value is its contribution to safety. The remote-controlled camera permits an operator to prepare for and conduct hazardous operations and critical tests without personal exposure to danger.

Thirty-six television cameras are in use at Redstone Arsenal, the headquarters of my Command from which we direct and manage the Army's many missile programs, and exploit our unique in-house capability for the design, development and fabrication of space vehicles. Six more such cameras are used at the Army missile launching facilities at Cape Canaveral. Seventy-two monitors, 36 master monitors and 18 slave monitors are tied into our circuits. Every test of solid and liquid-propellant rocket engines conducted at Redstone is covered by television. This serves two main objectives — safeguarding the personnel responsible for the test, as I have mentioned, and permitting key personnel removed from the test site to observe it, with a great saving in time and effort.

Elsewhere in our laboratories television provides continuing surveillance over hydraulic lines connected to a three-axis flight table, which can simulate actual missile flight. TV cameras keep a watchful eye on tests intended to insure the stability of nose cones during re-entry into Earth's atmosphere. Technicians observe the heat-resistant properties of metals and other substances by the same medium, benefiting from close-ups of the materials while destruction is occurring. The television camera allows engineers to watch closely the behavior of missile models in wind tunnels, or to monitor pre-launch preparations by troop units firing giant missiles in training.

At the Canaveral site the Army's missile-firing team can observe more closely the final steps in launching preparations from the safety of the blockhouse by means of color television. This technique even permits observation of the behavior of some functional systems inside the missiles. Engineers can read meters installed at the base of the missile to record fueling, at times when it would be extremely dangerous for them to be exposed in the area. They can follow the missile as it roars away from the pad, watching its movements in flight and observing closely the configuration of the rocket jet flame.

All of this is part of our elaborate system designed to provide maximum assurance of success every time a costly missile is launched, and to derive from each test the greatest possible amount of information about behavior and the functioning of each part.

Science of Optics Advanced

Moving to another field, I can assure you that the science of optics has also been advanced by the influence of our programs. Motion-picture and infrared photography are widely used.

Operating far down the Atlantic Missile Range, near the point of impact, Army technicians and Army contractor personnel have actually photographed with infrared equipment the elements of missile systems as they re-entered the atmosphere from space. These achievements have great scientific as well as military interest. A new type of trajectory measuring instrument, known as the BC-4 camera, has been developed under Army sponsorship. It is the most accurate recorder yet available. It is a ballistic camera which remains fixed in position and attitude and which records a trajectory by means of a

series of images imprinted upon a single plate. It is now used only for firings during the hours of darkness. A flashing light source installed on the missile provides the dotted image which traces the course. The Ballistic Research Laboratory of the Ordnance Corps is now investigating means to extend the coverage to daylight hours. One method would employ a shutter synchronized with movements of the missile. Only a small portion of the plate would be exposed at one time, and thus ambient light could not overexpose the sensitized plate. The other method would utilize a rapidly rotating shutter to "chop" the rocket's exhaust, which is a rich source of infrared. Other light is blocked out by an infrared filter.

By positioning two or more cameras, we can determine the missile's position in space by triangulation. The camera's position is determined by survey and its angular attitude by star calibration. The technicians are now looking into the possibility of using flame-chop techniques, and synchronizing the camera by radio link. Still another investigation will determine the feasibility of employing ground references for camera orientation and calibration.

Training Techniques

Now I want to discuss another phase of Army activity, which is wholly in tune with the keen interest taken by your Society in the guidance of students and advancement of high educational standards. I refer to the utilization of television and motion-picture techniques in the instruction of missile troops .... The Army has pioneered experiments for training soldier technicians at Redstone Arsenal.... Because these are novel systems, totally unlike conventional artillery, we must first train instructors, both military and civilian, before crew instruction can be initiated. To meet these accelerated needs, the Ordnance Guided Missile School has, with marked success, standardized teaching procedures. I will not discuss these procedures in detail, since the Commandant of the School, Colonel Henry Newhall, will describe and demonstrate them later on your program. I would, however, like to point out that the basic elements of the instruction system include television cameras, video tape, synchronized prompting devices, and closed-circuit projection.

Here I want to interject a warning. I feel the acceptance of these techniques in the general educational field can be inhibited by placing too much emphasis upon the completely automatic presentation. There is no substitute for the presence in the classroom of a responsible and competent teacher. Video tape, wide-screen techniques, faithful reproduction instantly in true colors of things and events provide realism which the teacher cannot inject by any other means. But they must be viewed as supplements to his trained efforts and not as ends in themselves.

Space Technology

There is also the area of space technology — the other major occupation which concerns us — that has real meaning to you as engineers especially interested in media for communications.

International capabilities for military and civilian exchange of messages and information are rapidly approaching the point of exhaustion. By 1962 the transatlantic cables carrying 36 voice channels will be swamped. A sevenfold increase in message units is anticipated in the decade after 1960. Long-range communications by telephone, telegraph and television are now carried by these cables, by land lines, long- and shortwave radio and microwave stations. The total bandwidth of land lines, cables and low-frequency radio is limited. Shortwave radio bands become unreliable under conditions of atmospheric interference and ionospheric irregularity. Ultra shortwave and microwave radio are limited to line-of-sight range and repeater stations must be provided to use these systems for long-range communications. Since a single TV channel is equivalent to 1000 voice channels, there is little possibility of extending this important medium on an international basis with presently known methods.

Confronted by this urgent need, we must look to the earth-circling communications satellite. These orbiters can be ideally suited to long-distance communications relay of all types. At the altitudes to be used line-of-sight range is greatly extended for ultra-shortwave and microwave radio transmissions. The bandwidths and channel capabilities potentially available could be quite sufficient for intercontinental television as well as all other foreseeable needs.

Both agencies of the Federal Government responsible for the direction of space programs are keenly interested in these possibilities. My Command is now engaged in developing a very large rocket booster for the Advanced Research Projects Agency. This will be the basic component of a multistage rocket system capable of orbiting communications satellites with world-wide transmission potential. As is well known, the major limiting factor in our space programs has been the limited thrust capability of boosters originally developed for weapons systems. The SATURN booster, as our baby is called, will multiply these capabilities several times, and will deal with energies of $1\frac{1}{4}$ to $1\frac{1}{2}$ million pounds.

Equipped with suitable transmission and reception equipment, a fleet of satellites in relatively permanent orbit could function as superbly efficient relay stations for the transmission of communications in video, audio, and code form. Operating far above the present sources of interference, they will usher in an age of international communications that holds out great promise for better understanding among the peoples of the world.

We are also exploring the use of television in reconnaissance devices to enable ground commanders to maintain coverage of the entire battlefield of the future (and) adapting satellites to weather observation, involving the world-wide detection and transmission to ground receiving stations of such data as the extent of cloud cover and the formation of storm fronts.

As our contribution to Project MERCURY, the "man in space" program of the National Aeronautics and Space Administration, we expect to give the carefully selected astronauts preparatory rides in a ballistic missile, the Army's REDSTONE. Preceding these manned flights will be other launchings to test the man-bearing capsule. REDSTONE was selected for the initial experiments because of its proven reliability.

Human Courage

As we move deeper into space, learning more about hitherto unknown phenomena which affect our present environment, and gaining new knowledge of that limitless environment beyond the sensible atmosphere, we must understand that we can progress only so far on the basis of theory and laboratory work. Then the issue has to be put to the proof of human courage and endurance. We will take every precaution to ensure success with safety, but there is no such thing as absolute assurance.

We must expect change. Scientific law is automatically amended when new knowledge appears. We must expect and plan for discoveries impossible to forecast in the limited light of our earthbound experience. I suggest, therefore, that we must consider that we have reached only the beginning of a new era of tremendous promise, which demands the maximum utilization of all our scientific knowledge, our technical skills, our strength of character, and our devotion to human progress. The professional fields you represent have the chance — and the challenge — to provide an important share of the leadership needed in this magnificent adventure. I am confident of the response, and I have great faith that the results will contribute substantially to the preservation of freedom and a better life for generations to come.

news and reports

86th Convention Papers Program/Exhibits

Early advice and commitments show many substantial sessions nearly crystallized in advance of the first deadline.

July 27 is the deadline for Author Forms to reach Topic Chairmen and the Program Chairman. If you have till now delayed advising the Society about a paper that should be on the Fall Papers Program, wire or telephone.

J. Paul Weiss
86th SMPTE Program Chairman
Du Pont Photo Products Dept.
Parlin, N.J.

Forms and advice are also available from the Papers Committee Regional Chairmen (see p. 247 of the April 1959 *Journal*) and from the 86th Program Topic Chairmen listed on p. 426 of the June 1959 *Journal*.

A Symposium on Film Steadiness has previously been announced and is now substantially organized. Two other subject areas to be especially noted at this time are best described by listing the tentative titles of papers.

Space Technology and Image Sensing
"Solar Photography"
"Satellite Astronomical Telescopes"
"Satellite Infrared Imaging Systems"
"Orbital Determination From Optical Tracking"
"Mars Pictorial Space Probe"
"Television and Moon Exploration"
"Image Sensors and Space Environment"
"Image Sensing From Earth Satellites"
"Space Stabilization for Image Sensors"
"Communicating Pictures From Space Probes"
"Television Uses for Man-In-Space Research"

Television
"Matching Dyes for Color Film vs. Picture-Tube Phosphors"
"A TV Studio Lighting Control System Employing High-Speed Digital Computer Techniques."
"General Problems of Color Television"
"Current Camera Switching Practices"
"Special Effects Amplifier — Monochrome or Color; Composite or Non-Composite Signals"
"Automatic Sensitivity Control for Monochrome Film Camera"
"High-Resolution Vidicon Television Camera"
"A New Transistorized Audio Console"
"Mechanical Features of a Video-Tape Recorder"
"A New 4½-Inch Image-Orthicon Camera"
"A New Automated Digital-Type Lighting Control Board"

Equipment Papers Session and Exhibit

A special session of papers describing or demonstrating equipment which is shown in the booths of the Convention Exhibit is scheduled tentatively for Tuesday morning, October 6. Chairman of this session will be Arthur J. Miller of Pathe Laboratories, Inc. The Society held its first such session at Miami Beach.

Exhibitors who contracted immediately after the announcement of the floor plan late in June were.

Arriflex Corp. of America
Bell & Howell Co.
Florman & Babb, Inc.
Karl Heitz, Inc.
Houston Fearless
JM Developments, Inc.
Macbeth Instrument Corp.
Neumade Corp.
Precision Laboratories
S.O.S. Cinema Supply Corp.
Vicom, Inc.

Reservations for booth space are being made by Exhibit Chairman William J. Reddick, c/o W. J. German, Inc., Jane St., Fort Lee, N.J.

AFITEC

The Association of Motion-Picture Engineers and Technicians of France (Association Française des Ingénieurs et Techniciens du Cinéma — AFITEC), established in 1947, was organized by its founders for the specific purpose of performing for its members in France the same functions that the SMPTE performs for its members in the U.S. During the Occupation, Jean Vivié, of the Commission Supérieure Technique, conceived the idea of an organization dedicated to the dissemination and exchange of technical information in the motion-picture field.

By 1947, the organization had become a reality, and at its inaugural meeting on January 10 of that year its first president, L. Didiée, spoke in these terms:

"Today marks not only the first meeting but the birth of the Association Française des Ingénieurs et Techniciens du Cinéma, which is none other than the French SMPE. . . .

"And now, what kind of organization shall AFITEC be?. . .Let us ask our predecessors. The SMPE in America was founded in 1916 by Francis Jenkins; it comprised at that time a dozen or so engineers and designers who met among the general confusion prevailing in the industry to organize a group dedicated to the advancement of the theory and practice of motion-picture engineering and of the arts that make it an object of daily use, the standardization of equipment and usage, and the dissemination of scientific knowledge by communication and publication.

"Our goal today is no different. You know what has become of those original dozen or so members. By the following year there were a hundred, and the Society was holding two general meetings a year; the papers presented at these meetings and the interesting discussions that resulted from them were published as the *Transactions of the SMPE* and appeared regularly until 1930. By that time, a monthly publication was judged to be necessary and all of you are aware of the reputation that this has now gained throughout the world. How many times each of us has turned to it, in translation, and how sadly we missed seeing it from 1940 to 1944, when it was no longer available. As for the meetings of the SMPE, these must be experienced, as I have had the pleasure of doing, in order to appreciate the wonderful spirit that pervades them.

"The officers of the SMPE are deeply devoted to maintaining the high level of their Society. This organization of engineers receives moral and financial support from important companies in the industry who encourage and sustain its activity, but no commercial taint is ever permitted to influence its work. The SMPE, which ten years after its foundation had increased tenfold, today is a hundred times larger than when it was started and has members in every continent; but its goals have remained the same. . . .

"I would propose a small organization after the model of the SMPE. . ."

The objectives of AFITEC are: (1) to promote the progress and development of motion-picture and related engineering; (2) to gather and centralize technical information and literature relating to motion pictures and their application; (3) to maintain liaison with organizations of similar aims in other countries; and (4) to act in the capacity of consultant, and to formulate recommendations, to official and corporate bodies in the field of motion pictures.

There are four grades of membership: founding members (the original group who organized AFITEC in 1947), active, associate and sustaining members. Officers consist of a permanent secretary (Jean Vivié); a president, elected for three years; a vice-president and an assistant secretary, elected for one year; and a treasurer, elected for two years. Candidates for president and treasurer must be chosen from among the founding members; those for the other elective offices may be founding or active members. The officers are elected at an annual general meeting by those members entitled to vote (founding, active and sustaining).

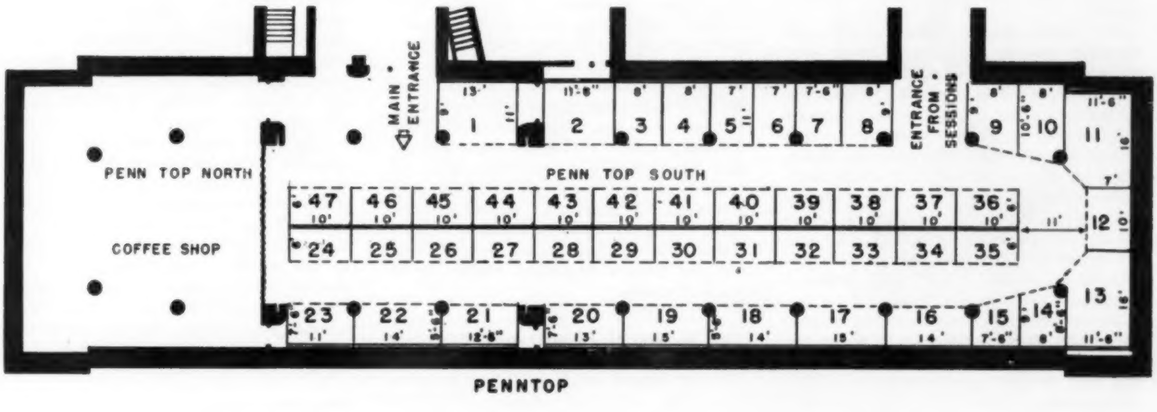
Technical meetings are held at irregular intervals, usually monthly, during the year, and a technical bulletin appears at least once a year. In addition, a number of special bulletins on historical subjects have been issued from time to time.

The headquarters of AFITEC is at 92 Champs-Elysées, Paris 8.

NEW YORK CONVENTION EXHIBIT

The newest developments in equipment, materials and information contributing to the future of the industry. See the latest advances in . . .

- cameras
- projection equipment
- magnetic/optical sound devices
- studio and projection lighting
- motion-picture processing and lab equipment
- editing-room equipment
- instrumentation and high-speed photography
- closed-circuit TV equipment
- laboratory services
- special effects
- production techniques



BOOTH RENTAL RATES

BOOTH NO.	
1	$600
2	460
3–7	360
8, 9, 16–19, 22	425
10, 20, 21	400
11, 13	550
12, 45–47	375
14, 15, 23, 36–38	350
24–35, 39–44	330

RESERVATIONS for booth space are now being made by the Exhibit Committee Chairman: William J. Reddick, c/o W. J. German, Inc., Jane Street, Fort Lee, N.J.

86th SMPTE SEMIANNUAL CONVENTION

STATLER HILTON HOTEL, NEW YORK

Exhibit Open October 5 thru 8

Education, Industry News

Transatlantic television (a one-minute newsfilm transmitted by B.B.C. over telephone cable) highlighted the visit of Queen Elizabeth II to Canada. The transmission of the one-minute newscast required 100 minutes. A total of 1400 pictures were transmitted. The film was developed and then transferred electronically to the telephone cable. The Canadian Broadcasting Corp. took the signals off the cable at Montreal and made a duplicate film which was carried over relay facilities to NBC-TV in New York.

The process, which was developed by the B.B.C. Engineering Division, employs a slow-speed flying-spot film scanner, the video signal from which is used to modulate a carrier for transmission over the cable. At the receiving end the signals are demodulated and used to operate a slow-speed film telerecording equipment.

In designing the equipment it was found that a maximum video frequency of 4.5 kc could be used. Certain economies were effected in the video signal: (1) restriction of the horizontal definition to that corresponding with a bandwidth of 1.75 mc in the 405-line system; (2) a reduction to 200 lines using sequential scanning; and (3) scanning at the transmitting end of only alternate film frames with each frame-scan reproduced on two adjacent film frames at the receiving terminal. These measures result in reducing the 3-mc bandwidth of the British system to approximately 450 kc, the remainder of the bandwidth reduction being obtained by a decrease of the scanning speed until the maximum video frequency corresponds with the available 4.5-kc upper limit. The time required to scan the film is approximately 100 times normal.

The system uses a channel of the type normally used for transmitting music over the cable; such a channel has a nominal bandwidth of 6.4 kc. In order to limit the variation in the group delay-frequency characteristic to a value that can be corrected, it is necessary to restrict the usable video bandwidth to 4.5 kc. Vestigial sideband transmission is used with a special form of negative-going amplitude modulation. The carrier frequency is 5 kc and the whole of the lower sideband is transmitted, the vestige of the upper sideband extending from 5 kc to 5.5 kc.

As in other television systems, a synchronizing signal is transmitted at the beginning of each line-scanning period, in this case, the full amplitude of the video signal being utilized for the triggering edge of the synchronizing signal. The field synchronizing signal consists of four similar pulses and protection as provided against these pulses interfering with the bursts of reference carrier which are used for oscillator locking.

Identical film equipments (16mm) are used at both terminals of the system. At the sending end, the apparatus operates as a flying-spot scanner while at the receiving end it functions as a telerecording channel. The same cathode-ray tube is used for both purposes and is enclosed in a double mu-metal shield to minimize lines frequency interference.

The time required for each field scan is approximately eight seconds. A separate monitor tube with a long persistence phosphor reproduces a recognizable picture. The special film traction mechanism, which is operated by the synchronizing signal pulls down two frames at a time. Twin optical systems are needed to record simultaneously on two adjacent film frames and very small lenses with a focal length of one inch and an aperture of *f*/8 were developed for this purpose.

An Internship Program for graduate students in audio-visual methods and and techniques has been announced by the College of Education and the Bureau of Audio-Visual Instruction of the Extension Division of the University of Colorado. Any Doctoral candidate who has been accepted by the Graduate School is eligible for consideration. Internship training includes course work, work experience, and guided college teaching. The program also extends financial assistance. Work experience will be provided by the Bureau of Audio-Visual Instruction and will include on-the-job training in the problems of Audio-Visual Administration. Interns who satisfactorily complete the training in conjunction with their other academic work may receive either an Ed. D. degree or a Ph.D. degree with a minor in Audio-Visual Education. Additional information is available from Dr. Robert E. de Kieffer, Associate Professor, College of Education, Univ. of Colorado, Boulder, Colo.

The Superintendents Viewpoint on Educational Television is a compilation of reports and opinions presented at a Panel Discussion before the Region I Conference of the National Association of Educational Broadcasters held September 20, 1958, in New York. Published by Thomas Alva Edison Foundation, Inc., 8 W. 40 St., New York 18, the 28-page booklet has also been distributed by the NAEB. Participants in the discussion included William M. Brish, Washington County, Md.; Harold B. Gores, Newton, Mass.; Calvin E. Gross, Pittsburgh; Allen H. Wetter, Philadelphia; and Maurice U. Ames, New York. A typical opinion is expressed by Mr. Wetter who said, "Of course, TV cannot take the place of the teacher. But I believe that in television we have one of the most effective teaching devices developed during my 41 years of service."

The Society of Photographic Scientists and Engineers has announced the appointment of Nelson W. Rodelius as Program Chairman and Charles E. Ives as Papers Chairman for the 1959 National Conference to be held October 26–30, at the Edgewater Beach Hotel in Chicago. Mr. Rodelius is associated with the Armour Research Foundation in Chicago. Mr. Ives is a research associate at Kodak Research Laboratories, Rochester, N.Y. Other Chairmen are: Arthur E. Neumer of Rochester, Exhibits; Joseph Mangiaracina, Little Silver, N.J., Registration. The Treasurer is Walter Rybka of American Speedlight Corp., Middle Village, N.Y. A large foreign delegation is expected at the Conference, including visitors from Germany, France, Australia and Japan. The Exhibit to be held in conjunction with the Conference will feature photographic and electronic equipment.

Central Africa's first industrial film company, Associated Rhodesian Telefilms, P.O. Box 8252 Causeway, Salisbury, Southern Rhodesia, Central Africa, has been organized and is owned by Geoffrey Mangin. Mr. Mangin presented a paper at the Fall 1958 Convention in Detroit. At that time he was associated with the Central African Film Unit. In a letter to the *Journal* announcing the new company, Mr. Mangin reports: "Things have been happening very rapidly (in) Africa . . . details are being finalized to start television in Central Africa next year. The new firm will produce mainly 16mm films for industry. Besides producing films for specialized audiences and local television (beginning next year), the organization will also supply 16mm or 35mm topical film material from any part of Africa south of the equator to overseas producers and television companies."

Peachtree Production Associates, Inc., of Atlanta, Ga., has announced that it has acquired the management and control of Strickland Films, Inc., as part of an expansion program planned eventually to include video-tape production and syndication of several TV film series. The firm has moved its production facilities to Strickland Studios, 220 Pharr Rd., N.E., Atlanta 5.

Motion-picture film which had been soaked in the salty South Atlantic for more than half an hour following the Thor missile flight on May 12 developed successfully into the first movies of one space vehicle taken from another. The pictures were taken from a data capsule in the missile's nose cone which enclosed a tiny camera and 40 ft of Kodak Plus-X Reversal film. Photographed at altitudes approaching 300 miles, the film shows the booster snapping away from the nose cone, then falling away below as the cone continues upward. In the background, the earth and its cloud cover show as a hazy white half-circle outlined against the black void of space. From Cape Canaveral, the nose cone raced 1500 miles in 15 minutes to land in the Atlantic near Antigua. The data capsule, ejected just before impact, emitted signals to guide its recovery. Immediately after its recovery the film was placed in an airtight container to keep fogging of film by salt water to a minimum.

The Commission International de l'Eclairage met in Brussels, June 11 to 24. The Commission is planned to provide an international forum for all matters pertaining to the science and art of illumination, to promote the study of such matters, to provide for interchange of lighting information among countries, and to agree upon and publish international recommendations. Thirty-six countries were represented at the meeting. Among U.S.A. delegates was Karl Freund, President of Photo Research Corp. of Hollywood, who represented motion-picture and television lighting. Dr. Freund is the author of numerous articles in this *Journal*.

Dr. S. K. Guth, also a *Journal* author, from the Lamp Division of General Electric Co., Cleveland, was Chairman of the CIE Committee on Causes of Discomfort in Lighting. Chairman for the CIE Committee on Colorimetry was Dr. Dean B. Judd of the National Bureau of Standards. T. M. Edwards, Grimes Mfg. Co., Urbana, Ohio, was Chairman for Airborne Lighting and Signals, making a total of three U.S.A. chairmanships among the 16 international Technical Committees.

Guild Films Co., 460 Park Ave., New York 22, has moved its sales and administrative offices to 655 Madison Ave., New York City, and 32 Court St., Brooklyn, because of expanding activities due to the increasing video-tape market and the growing international operation of Inter World TV Films, the firm's international distributor, which now reports representatives in major TV markets throughout the world.

Space Recovery Systems, Inc., a new organization formed to provide research, engineering and production for advance recovery systems designed to retrieve equipment and personnel from high altitudes, has established its main offices in El Segundo, Calif. A combined operation of CBS Laboratories and M. Steinthal and Co., the new organization will continue the work of AERCO (Aeronautical Equipment Research Corp.), a Steinthal subsidiary, which it has absorbed.

Nautilus Arctic Passage is a 14½-minute documentary film in sound and color depicting the historic voyage of the nuclear-powered submarine, USS Nautilus, from the Pacific to the Atlantic in mid-1958. The film was produced by the Motion Picture unit of Autonetics, 9150 E. Imperial Hwy., Downey, Calif., in cooperation with the Navy. Highlights of the film include spectacular views of the under side of the Arctic ice pack and voice recordings of Cmdr. William R. Anderson at the moment of crossing the North Pole. The film is available without charge for public, nonprofit, television and theatrical exhibition.

Lift Thine Eyes, a 20-minute motion picture dramatizing the training of a student nurse has been made by advanced students in the Department of Radio, Television and Film, School of Speech, Northwestern University at the request of Evanston Hospital, Evanston, Ill. Production of the film was undertaken for credit as independent study. This film and an earlier one, *A Better Beginning*, on the Premature Babies Milk Bank, are available for loan, without charge, from the University's film library.

An authority on sensitization of film, William West, of Eastman Kodak Co., described the photographic process in a talk on "Photoelectrons and Photographs" given May 2 before a joint meeting of the Chemistry Teacher's Club of New York and the Physics Club of New York. The meeting was held at Fieldston School, New York. In his talk, Dr. West described the process by which light of a certain color sets in motion a chain of events from which the final picture can be derived. He also discussed sub-atomic changes caused by light in film, and spoke of phenomena now under study at Kodak Research Laboratories.

Allan C. Finstad has been appointed Education and Professional Products Manager for Dage Television, a division of Thompson Ramo Wooldridge, Inc. For the past two years, he has been manager of the audio-visual products department of Ozalid division of General Analine & Film Corp., New York. Prior to that he was educational director and audio and visual aids supervisor for the Charles Beseler Co. Mr. Finstad is the author of a *Journal* paper, "Preparation and Presentation of Low-Cost Projectable Materials," pp. 461-464, Aug. 1957.

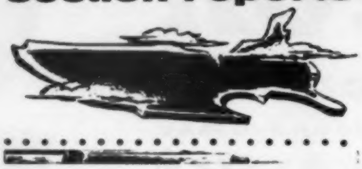
James W. Hulfish, Jr., has been appointed Director of Information for the National Audio-Visual Association, Inc. He succeeds Henry C. Ruark who recently accepted an appointment to the Oregon State Department of Education. In his new post Mr. Hulfish will be responsible for the Association's trade and public relations programs, including press publicity. He will also edit NAVA News. Prior to his present appointment he was Administrative Assistant to the Executive Vice-President of the U.S. Wholesale Grocers' Association, Inc.

George T. Scharffenberger has been appointed a vice-president of Litton Industries, Inc., in which capacity he will serve as President of Westrex Corp., a Litton division. He succeeds Glen McDaniel, vice-president and general counsel of Westrex who becomes Chairman of Westrex. Prior to his present appointment, Mr. Scharffenberger was President of Kellogg Switchboard and Supply Co., a division of International Telephone and Telegraph Corp.

Norman E. C. Naill has been appointed Customer Relations Representative for Southwest Film Laboratory, Inc. Prior to this appointment he was Motion Pictt re Production Supervisor for Virginia Polytechnic Institute. A member of the Society, he is also a member of the University Film Producers Assn.

Victor A. Babits, Professor of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N.Y., has been made a Fellow of the Television Society, London, England, for "contributions to television over the past thirty years or more." The Television Society, founded in 1927, is said to be the first such group organized tc further research in television.

section reports



The Hollywood Section met on May 19 at the Walt Disney Studios in Burbank with an attendance of 220. Speakers were: Vaughan C. Shaner and John M. Waner of Eastman Kodak Co., who discussed "High-Speed Eastman Color Negative Film;" and James DuBois of KABC Television, who talked about "Special Lighting Effects Using the Leco Spotlight and a New Cukaloris."

Mr. Shaner spoke on the new Eastman color negative film Type 5250, which was designed to replace Type 5248. He used colored slides to show that 5248 and 5250 are directly comparable as far as spectral sensitivity is concerned, but 5250 has twice the film speed of 5248. In a 35mm print showing identical scenes photographed on 5248 and 5250, the Type 5250, with the increased emulsion speed, permitted exposure at one lens stop less light under the same lighting conditions. The color from the 5250 matched the 5248 very closely, and the effect of stopping down the lens was quite apparent in the increased depth of field. The closing portion of the film showed scenes from the 1959 Ice Follies of Shipstead and Johnson, using lighting conditions exactly as they were for the road show. Following Mr. Shaner's presentation, Mr. Waner discussed some of the technical aspects of printing and processing the new material.

Mr. DuBois outlined the procedure used in preparing masks for use in Leco spotlights to project special background lighting effects as used in TV. He showed, step-by-step, illustrating with colored slides, how the special pattern masks are made from a photographic negative and transferred to a very thin aluminum disc by photoengraving methods. The extremely fine detail of a special mask was shown, and several masks were inserted in the spotlight and the effects displayed on the screen for the audience to see.—Carl W. Hauge, *Secretary-Treasurer*, 959 N. Seward St., Hollywood 38, Calif.

The Hollywood Section met on June 16 at the Department of Cinema, University of Southern California, Los Angeles, with an attendance of 175. Frank P. Clark, chairman of the SMPTE Student Chapter at the University, conducted the meeting and introduced the speakers.

Robert W. Wagner, then Head of the University's Cinema Dept., discussed "USC Cinema and the Next 30 Years." Glenn D. McMurry, Manager of Film Sales, talked about "Automation in Film Cataloging," and John G. Frayne, Westrex Corp., discussed "The Engineer and the Motion-Picture Industry."

In addition to the three papers, various motion pictures made by students from several academic levels in the Cinema Department were presented. The graduate department presented a film made from clippings and behind-the-scene shots from *Bridge on the River Kwai*, which showed how to prepare dramatic shots to greatest advantage to make the experience believable and the characters and their conduct real.

Mr. McMurry described how the IBM card system is used for the rapid up-dating of film catalogs.

Dr. Frayne spoke of the obligation that industry has to support technology development and the technical training programs for up-grading personnel of the motion-picture and TV industries.

The USC Student Chapter is a particularly active group and this program, arranged and presented by them, showed some of their fine work. The facilities of the USC department were open for inspection. —Carl W. Hauge, *Secretary-Treasurer*.

The Rochester Section met on May 21 at WSYR-TV in Syracuse with an attendance of 42. Robert A. Storme of Ampex Corp., New York, was the guest speaker.

Mr. Storme supplemented his excellent discussion of the Ampex Videotape Recorder with a slide and tape talk normally used by the Ampex Corp., in the promotion of its equipment. With the assistance of WSYR personnel, an interesting demonstration of the equipment was made in which the audience was recorded and the same picture information was played back so that everyone could see the quality available in this system.

Following Mr. Storme's presentation, the management and personnel of WSYR conducted the group on a tour of the station's facilities.—R. E. Connor, *Secretary-Treasurer*, 35 Chatham Park, Rochester 18, N.Y.

The San Francisco Section, following cocktails and dinner at the Zombie Village, met on April 14th at the Tinsley Optical Laboratory in Berkeley with an attendance of 43. The subject of the evening: Optics.

Since 1942 the Tinsley Laboratory has been specializing in the research and development of optics. Their primary field is long focal length lenses that are physically small. Their 40-in. 3.5 lens has a total overall length of only 20 in.

H. L. Morton of the Tinsley Lab. talked about lenses in general and gave a complete description of the schlieren, shadowgraph and interferometer systems, the methods most commonly used for the study of gas-density variation. The schlieren system has proved most versatile for wind-tunnel application. Lenses in various stages of construction were inspected by the audience.

A tour of the Laboratory followed Mr. Morton's presentation. Several polishing and grinding machines were in operation and a complete schlieren system, constructed for Douglas Aircraft, had been set up for the inspection of the audience. In place of the wind tunnel, a nonflame heat device was used to simulate shock waves for the demonstration.—Frank Mansfield, *Secretary-Treasurer*, 57 Stoneyford Ave., San Francisco 24, Calif.

The San Francisco Section held a joint meeting with the Audio Engineering Society on May 11 at the Morrison Planetarium in San Francisco. The meeting, in two parts, was attended by 109.

Part one was a demonstration and explanation of the basic principles of "Vortex." Henry Jacobs and Jordan Belson, co-inventors of Vortex, were the main speakers. Mr. Jacobs explained the sound portion and the electronic tone generated music while Mr. Belson talked about the types of projection equipment used for the visual portion of the demonstration. A typical program was shown. Vortex was shown at the World's Fair in Brussels in 1958.

The second portion of the meeting was devoted to the Planetarium in Golden Gate Park. Alvin C. Gundred, Planetarium Technician, described the equipment in use and explained how most of it was constructed. Both the audio and projection portions were covered. George W. Bunton, Manager of the Planetarium and Curator, Department of Astronomy, California Academy of Sciences, spoke on the general history of the installation and ran a portion of a typical show.—Frank Mansfield, *Secretary-Treasurer*, 57 Stoneyford Ave., San Francisco 24, Calif.

The San Francisco Section met June 9 at the studios of the American Broadcasting Company with an attendance of 25. Speakers at the meeting were: Thomas R. Simonson, G. M. Simonson Consulting Engineers, who discussed "Heating, Ventilating and Noise Reduction in Studios," and W. A. Palmer, Palmer Films, Inc., whose subject was "Acoustical Treatment of Studios."

Mr. Simonson discussed the problems of air conditioning, the various methods used and problems encountered in their applications, the factor of percent humidity to comfort level and the control of the noise of the systems.

In his discussion of acoustics, Mr. Palmer used slides to illustrate the basic types of studio and theater design and the reasons for their use, the various materials used and the proper way to use them. Typical reverberation and decay-time charts were discussed. The meeting was concluded by showing advantages and disadvantages of several studio and theater designs.—Frank Mansfield, *Secretary-Treasurer*, 57 Stoneyford Ave., San Francisco 24.

Spotlight on

Gevapan 30, Type 165 is favored by experienced cameramen all over the world. This film gives uniform results, even when the shooting schedule calls for both interior and exterior shots. The fine grain and excellent gradation give extremely good definition with excellent tone rendition. The special sensitivity of this film also minimizes make-up and other photographic problems.

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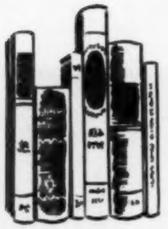

books reviewed

Commercial Television

By Wallace S. Sharps. Published (1958) by Fountain Press, 46-47 Chancery Lane, London, W.C. 2; distr. in U.S. by Rayelle Publications, 76 West Chelton Ave., Philadelphia 44. 496 pp. (incl. 69-page glossary). 336 Illus. $5\frac{1}{2}$ by $8\frac{1}{2}$ in. Price $14.95.

"In this book I have tried to provide a storehouse of information that will be of value in the day-to-day work of advertisers, advertising practitioners, film makers, the staff of the programme contractors and all those who earn their living through commercial television, or are interested in its development and exploitation." Thus, in the author's own words is stated the purpose of the book.

From an American point of view, the title of the book might well have been "Commercial Television in England," for it is primarily documented with the experiences of the first two years of commercial television broadcasting in England, London to be specific. However, it is interesting to note that the language of television is remarkably similar, whether it applies to techniques employed in London or those of New York and Hollywood. Since this is a book dealing with basic concepts and techniques, it could well be used as a text in television courses from Compton to Cambridge, Ohio State to Oxford, and Michigan to Melbourne.

Though intended primarily for a production personnel clientele, the book contains a remarkable collection of data relative to technical operations of television and film equipment. Significant technical developments from Baird's disk scanner through present-day magnetic-tape recorders are described, including a comparison of English and United States transmission standards.

Five of the 25 chapters are devoted to various aspects of motion-picture film usage for television, from the structure of the raw film stock through developing, printing, editing, sound recording, animation, and TV projection. One chapter is devoted to "Optical and Magnetic Telerecording" in which various British approaches to what Americans call kinescope recording are described in some detail with appropriate illustrations. Included also are brief descriptions of the various approaches to magnetic recording of television including the current American techniques and the BBC's VERA machine which employs a half-inch tape running at 200 in./sec.

Illustrating the wide scope of this book are two chapters titled "Audience Research," and "The Law Relating to Commercial Television." The latter is obviously English

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This is not intended as a slur on the many fine film makers who are not located in New York, Chicago and Hollywood. The top Pros throughout the world are also loyal CECO patrons. Whatever the need, if CECO can't solve it, who can?

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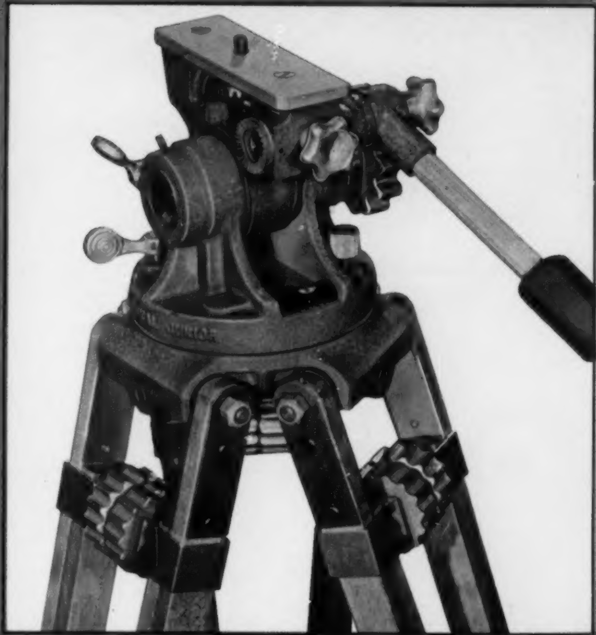

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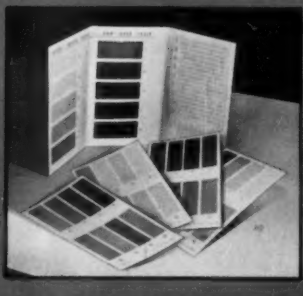


SHARPS Colour Chart and Grey Scale

Indicates how colors will reproduce in monochrome when photographed by film or TV cameras. Insures correct evaluation and choice of colors for desired effects.

law, not American law, though there is no doubt much similarity in the laws of the two countries.

The last chapter is in itself a unique and valuable collection, for it is a 68-page dictionary of commercial TV terms, covering all aspects of the medium. Herein, ASA standards are frequently listed as references.

Without doubt this is a well organized, well written, easy reading, storehouse of practical information concerning commercial television, particularly that of Britain, though applicable in large part to television in any land.—*Ralph E. Lovell*, 2554 Prosser Ave., Los Angeles 64.

Perspective:

Quarterly Review of Progress in Photography, Cinematography, Sound and Image Recording. Vol. 1, No. 1, 1959.

Edited by A. Kraszna-Krausz. Published by Fountain Press Ltd., 31 Fitzroy Sq., London, W.1. 112 pp. plus 10 pp. advertisements. 7¼ by 9¾-in. Price (subscription) $7.50.

In three volumes called *Progress In Photography*, published by Focal Press, Ltd., in 1951, 1955 and 1958, respectively, were described changes that occurred from 1940–1958. Now a new publication has appeared, called *Perspective* and intended to "look out through the present towards the future." Changes in the photographic industry, its market, applications and techniques of photography and even the changing language will be reviewed.

This initial issue is attractively printed and bound in flexible card covers. Approximately two-thirds of it is devoted to eight short articles written by well-known authors. The titles of these articles are: "What Price Amateur Photography"; "Not by Silver Alone"; "Focus on Natural History"; "The Professional Tool"; "All the Color"; "Training German Photographers"; "Pictures on Tape"; and "The Growth of American Photography."

Of these, possibly three have some interest to motion-picture or television engineers. "Not by Silver Alone" by Martin Hepher classifies several systems of photography which do not utilize silver halides as the primary light-sensitive media. "All the Color," by George Ashton, presents a survey of the color materials for still photography and their relation to each other. The article of greatest interest is probably W. H. Cheevers' account of "Pictures on Tape," which describes the fundamentals of video tape for recording and reproduction and its use in the United Kingdom.

The latter third of this issue is devoted to 47 well-written abstracts on research reports, products and methods. Some of the subjects covered are: "Color of Electron Images," "TV Tube vs. Film in Spectrography," "Cine Cameras for Missiles," "10 Seconds Processing," "Perforated Tape Synchronization," "Earth Satellite Tracking," and "Photographing History."

A group of 9 short abstracts of market conditions concludes the issue. Information is given on West Germany, Japan, U.S.S.R., France and the United States.

In the preface mention is made of a plan to publish a new series of monographs entitled, "The Progress Library of Photographic Science and Technology" as the individual areas of specialization are considered beyond the scope of "Perspective."

A general comment is that this new quarterly presents a fresh, intelligent and interesting approach to the old problem of a progress report. It is hoped that succeeding issues will be equally refreshing.—*Glenn E. Matthews*, Eastman Kodak Co., Research Laboratories, Rochester, N. Y.

The Animated Cartoon

By John Daborn. Published (1958) Fountain Press, 46-47 Chancery Lane, London W.C. 2. 204 pp. 7 by 5-in. Paperbound. Illus. Price 2s 6d (35 cents).

This paperbound booklet is primarily of interest to amateur film makers desiring a capsule knowledge of animated cartoon methods. It would likewise be of passing interest to live action film makers who would like a superficial insight into some of the basic problems and techniques of the cartoon film.

The booklet, for all its brevity, does have a remarkable amount of information for the uninitiated, covering the basic principles, homemade equipment that can be made for drawing and setting up a camera, and several available systems to produce both simple and relatively complex animated films.

Items under discussion include the building of an illuminated animator's drawingboard, and two types of inexpensive animation stands for substandard film cameras.

The first is a four-poster wooden stand with adjustment for varying camera-to-subject distance, but not permitting zooms. The second is much more elaborate and, if properly constructed and used carefully with a lightweight camera, would permit the photography of approach shots suitable for use in amateur filming. Both units are illustrated with line drawings of sufficient clarity to enable anyone with a reasonable amount of mechanical ability to construct either unit.

Basic animation methods mentioned include using high-contrast film and pencil drawings. Backgrounds handled on cels allow some saving of labor. A variation of this same system using cutaway sections is also shown. The more conventional and up-to-date methods used by the large studios in professional production are next mentioned, as are many of the basic principles of motion breakdown of the drawings themselves. Repeat cycles, sliding cels and camera animation are very briefly covered. A paragraph is devoted to silhouette animation for individuals who don't have sufficient drawing ability to indulge in full-scale animation.

The balance of the booklet is devoted to brief mentions of various techniques and problems, scratchoff with reverse action, diagrammatic animation, lining up the camera, field chart, focus, tests, wipes, dissolves and trucking.

It must be remembered that the terminology in this treatise is British, but this will not in any way confuse the reader because the text is very clear.

It is regrettable that the author was not permitted more space to dig more thoroughly into the matter at hand, to make it a more valuable book.

As the author intended, amateur film makers interested in the field of animation will find both the text and illustrations of interest, giving a brief run-through on the basics of animated cartoon filming. The professional, already in the animation industry, on the other hand will find nothing in this book, as it is too elementary.—*Ernest M. Pittaro*, Tri-Film Studio, 137–73 70th Ave., Flushing 67, N.Y.

The Art of Animation

By Bob Thomas. Published (1959) Simon and Schuster, Inc. 630 Fifth Ave., New York 20. 188 pp. 8½ by 11¼-in. Illus. Price $5.95.

This volume, although a very well designed and appealing book, is strictly a popularized presentation of the animated cartoon technique. It never was intended as a technical discourse on the subject as its colorful illustrations and elaborate make-up appeal to the layman and to youngsters who may have a passing curiosity in this direction.

Despite the popular approach, there are some interesting facts and illustrative reproductions which are probably of sufficient interest to the student of animation, or to those in the film industry who are not conversant with the medium. After reading the book, the student, layman or teenager will undoubtedly have an insight into the multifaceted problems of animation, and have a greater appreciation of the animated film when next seen in the theater. For young people, this book may very well serve as an aid to inspiring a serious interest in the animation industry.

Many aspects of the production of animated cartoons are discussed. Matters that are usually left out of popularized magazine articles are covered, and for this reason the book gives a good account of itself for a popularized treatment.

The first chapter is a very brief history of animation which is far from complete, but does indicate some of the antecedents of present-day cartooning. Story material, and some of the steps in preparing story material for the screen are discussed. Character derivation and design are demonstrated quite thoroughly and aided by a profusion of black-and-white as well as color illustrations.

Both the technical and creative phases of the production of soundtracks are touched upon, including voice, effects and music tracks.

Direction, a much neglected phase of animated cartoon production is well covered from a number of standpoints, and will undoubtedly awaken in the lay reader a realization that cartoons don't just happen, but are built upon a careful foundation of planning.

This is further amplified by the chapter on Layout, which clearly shows the way in which camera-fields are planned, and their relationship to the finished film. Multiplane camera is shown in photographs

and diagrams, demonstrating the application of the layout planning.

The chapter on Animation is of interest to the student interested in the drawing aspect of the animation profession, and the same can be said for the chapter on backgrounds. A number of interesting facts are brought out in these two chapters, facts that go beyond the expected scope of such a popularized book. Details of the drawing techniques, and some of the color problems come in for a cursory investigation.

The last page of text expounds upon the future of animation, and admittedly this reviewer is prejudiced against prognostications of any sort as a waste of time. The appendix includes animators' credits for feature production, a glossary of animation terms which is useful for the student and layman.

The profusion of beautiful color and black-and-white illustrations makes this book a worthy addition to the library of anyone interested in the film medium. For the individuals in the animation profession, the illustrations may serve as an interesting record of some of the Disney productions, but of course the information given is too rudimentary to be of much value to the professional.

In summary, this book is of value to the layman, student or person with limited or no knowledge of the animation process, or for those who collect books pertaining to film as an art medium. To the professional, the book is only of passing interest, since it does not pretend to be a deep technical discussion of the subject.—*Ernest M. Pittaro*, Tri-Film Studio, 137–73 70th Ave., Flushing 67, N.Y.

My Ivory Cellar:

The Story of Time-Lapse Photography, By John Ott. Published by Twentieth Century Press, Inc., 40 S. Clinton, Chicago. 157 pp. 6¼ by 9¼-in. Illus. Price $4.75.

This fascinating and informative book will be of interest to anyone with a serious interest in some of the lesser-known phases of motion-picture work.

The author has not set out to instruct the reader in the details of building and operating time-lapse equipment setups, but rather chronicles the history of some of his own experiences in the field. In the course of the detailed descriptions, much information can be gleaned, particularly the avoidance of potential pitfalls for the tyro in his initial attempts in this field.

Included in the book are several electrical diagrams of time-lapse control equipment which, if followed, put the reader well onto the right track in constructing his own apparatus. Careful reading, and rereading of this book, plus detailed examination of the many photographs would permit anyone interested to embark upon his own time-lapse work with confidence, and the comforting knowledge that he has been guided by an expert.

The book's sphere of interest goes far beyond that of limiting itself to those who intend to go into time-lapse work. It is of very general interest as well, since it is a factual account of the history of the development of present-day time-lapse techniques, tracing all of the failures, the difficulties, the discouragements and the ingenious solutions to the most frustrating problems imaginable.

It is a most thought-provoking book in another way; the author indicates many discoveries that were made incidentally while working in this intriguing field of scientific research, discoveries that have prompted large manufacturing concerns to start research projects based upon the time-lapse findings.

The reader is soon made aware that there is more to time-lapse work than setting up a camera and photographing flora at given intervals. This field of endeavor leads to many varied fields such as cancer research, rehabilitation of criminals, the effect of natural and artificial light on mental and physical well being, a variety of information about plant life and interesting sidelights on the transmission of certain wavelengths through plastics and glass.

One of the most impressive aspects of time-lapse work as described in this book is the vast amount of attendant equipment that is necessary for the pursuit of serious work in this field. The very nature of the work demands that an individual camera be tied up for months on end. This indicates that if more than one project is to be handled at one time, a camera and control equipment must be earmarked for each setup. In addition, precise temperature and humidity controls, automatic shade controls, light controls, as well as special construction of housings around trees and other plants are all necessary to the successful completion of finished film.

The book is somewhat autobiographic, written in an easy and lucid style leading the reader from subject to subject with as much suspense as a mystery story, and this reviewer had great difficulty in putting the book down.

Anyone having an interest in serious scientific photography, research, the challenge of solving problems and the stimulation of thought, will find **My Ivory Cellar** a most absorbing and worth-while book.—*Ernest M. Pittaro*, Tri-Film Studio, 137–73 70th Ave., Flushing 67, N.Y.

The Dress Doctor

By Edith Head and Jane Kessner Ardmore. Published (1959) by Little, Brown & Co. 249 pp. + 8 pp. illus. 5⅜ by 8 in. Price $3.95.

This autobiography of Edith Head, fashion designer, U.S.A., is a real, live success story. Miss Head is a successful career woman of outstanding ability. Fashion Chief of Paramount Pictures, Hollywood, she has the distinction of being the *only feminine* six-time winner of filmland's top award of merit, The Academy of Motion Picture Arts and Sciences Oscar. And the basis for the Awards is *not* originality or beauty of costume design but for how much they contribute to the overall excellence of the motion picture.

A native Californian, Edith Head was born in Los Angeles and recalls her early, lonely childhood on the desert near Searchlight, Nevada, a "gold" town where her stepfather was a mining engineer. Cactus,

pliant greasewood, and desert flowers were the first tools of her trade — horned toads, dogs, cats, jackrabbits and burros her models — and imagination her studio. Miss Head graduated from the University of California and Stanford University with A.B. and M.A. degrees and subsequently attended Otis Art School and Choulnard Art School in Los Angeles. Later she taught French, Spanish and Art at the Hollywood School for Girls and The Bishop School for Girls at La Jolla, Calif. To fill in with a temporary summer job, the ambitious young schoolteacher answered an ad for a sketch artist at Paramount Studios, was accepted, and reached a decision. "There was a magic power in clothes . . . they could develop personality. I decided to stick with them." She came up the long, hard way via every lowly chore in the fashion department until she ultimately won her place as the studio topper in Fashion Design.

Miss Head is able to sweep aside the glamor curtain of the Hollywood scene and take us onstage to meet realism in terms of fashion and design for the woman in the home. Her dedication of this timely work is "To Mrs. Average American." In *The Dress Doctor* she comes up with many practical, economical suggestions. A "color chart" is set forth in detail (p. 214) from which are quoted below a few definitions based on "mood and key" and proven "highly successful" in Miss Head's operation:

Hot Colors (intense, strong): Magenta, Flame, Burnt Orange, Electric Blue

Relaxing Colors (soft, grayed): Ivory, Rose Beige, Powder-blue, Sea-green.

Some women dress for women but the vast majority of women dress for the admiration of the male and you'll enjoy the chapter "The Masculine Point of View" and the enlightening quips and sundry fashion flips from well-known actors and director-producers.

With a keen perceptive sense of human nature and basic values, Miss Head is quick to spot the phony femme who affects the spectacular and who has "gone Hollywood." But, in stride, she deals with these characters—in fact, "you learn, too, from the less talented, the ambition-driven, the would-bees." Nice going, there, Miss Head!

And you'll really appreciate a day on the studio set after you've read of Edith Head's one and only semi-hysterical appearance before the cameras as an actress in the role of the chic owner of a dress salon in the picture *Lucy Gallant*.

Across the VistaVision screen of this entertaining and informative work parade is projected a glittering array of stars, newcomers and former boxoffice 'greats' many of whom have carved new careers in television. But Marlene Dietrich and Gloria Swanson earn special niches in Edith Head's filmland hall of fame as "all-time symbols of glamor."

A versatile person in her chosen profession is Edith Head: she has designed gowns and costumes for the circus, for ice shows, for opera, nightclubs, state inaugurations and, of course, television. She admits to "a photographic mind" which is an invaluable asset to her in the retention of fashion essentials gleaned in her daily observations as witness these quotes:

"Fashion is a language — some know it — some learn it — some never will.

"The cardinal sin is not being badly dressed but wearing the right thing in the wrong place.

"Good clothes should be comfortable.

"Better than 'elegant' to me is *appropriate*.

". . . too high fashion frightens some people.

"Good clothes have no *age*.

"A dress should be tight enough to show you're a woman and loose enough to prove you a lady!"

Never center-of-the-road in her pronouncements and decisions, it must have required untold diplomacy and tact to avoid compromise with some of the opinionated characters who hide behind the mighty production desks in the palatial studio offices. But it's paid off for Edith Head and today she is the recognized arbiter of fashion in hectic Hollywood.

The book is fascinating reading and it's all very human and warm. We salute you, Edith Head, for your unselfish contribution to the arts and sciences of the motion picture — and of television.—*Solita Palmer*, P.O. Box 265, Three Arch Bay, South Laguna, California.

(*Ed. Note:* This review by Miss Solita Palmer, member of ASCAP and AGAC, and composer of original music for films and TV, is intended primarily for the distaff side of the motion-picture and TV industries but is also directed to any person concerned with direction or production of films or television.)

Motion Picture Technical Dictionary: English-French; French-English

By C. Ryle Gibbs. Published (1959) by La Technique Cinématographique, 54 Rue de Clichy, Paris 9e. 244 pp. 4½ by 6 in. Price 1960 F.

Perhaps the most attractive thing about this new dictionary is its size. At last we have a list of French and English motion-picture terms that is neither part of a bulky multilanguage glossary, nor an appendix to a fat yearbook weighing a couple of pounds. This is a small volume that could even be carried in a pocket without too much damage to a jacket, and consequently it should prove very useful to those who have need of such help in their daily work.

There are no definitions given, but the list of motion-picture terms appears to be more complete than in any of the comparable compilations, and should contain everything needed for describing operations in any part of the industry. In fact, the absence of definitions or other elaborations is in a sense an advantage, since it ensures a page that is uncluttered and easy to use.

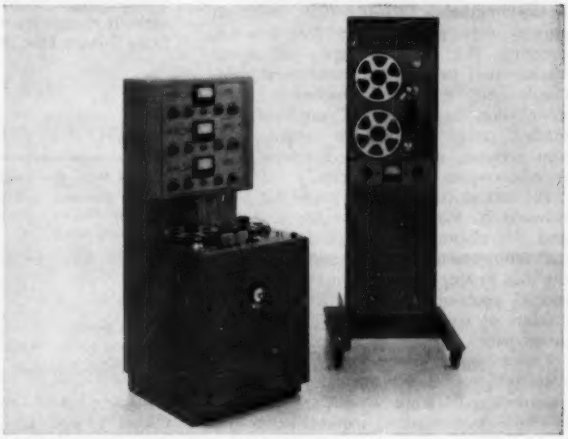
Mr. Gibbs, who has had a distinguished career in the motion-picture industry in England, France and India, and who has been a member of SMPTE for many years, is to be complimented on his achievement in producing this very useful dictionary.

AMPEX

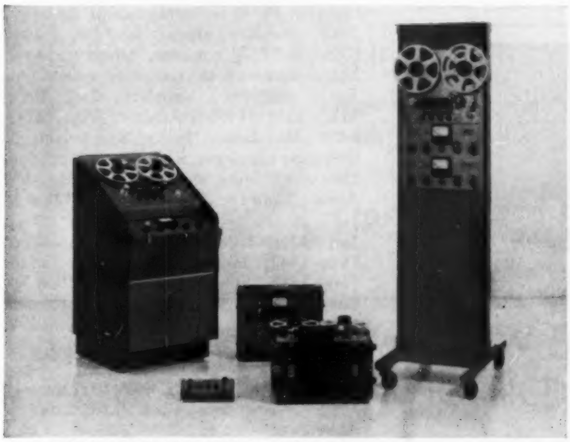
World Leader in Precision Magnetic Tape Recording Instruments

Ampex Tape Recorders are in service throughout the world in television and radio stations, and in professional sound recording studios . . . wherever finest quality is required.

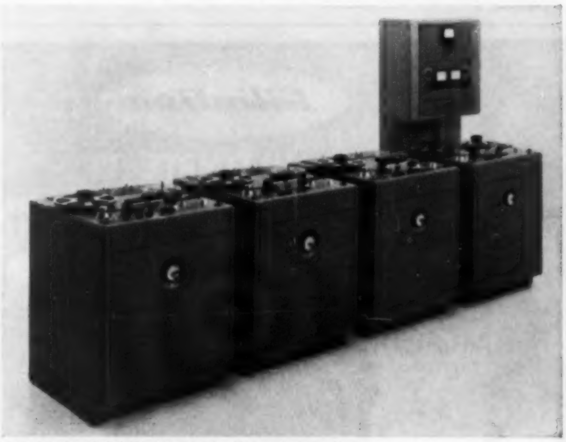
VR-1000 *Videotape* Recorder*
First commercially available Videotape Recorder. Magnetically records what the TV camera "sees," in either black and white or color. Playbacks look "live."



MODEL 300 *Magnetic Tape Recorder*
Standard of the professional recording industry, it consistently delivers the finest in audio reproduction. Available in as many as 8 channels, in console and rack mounting.



MODEL 351 *Magnetic Tape Recorder*
First choice of the broadcasting industry. Features printed circuits and miniature tubes. Available in console, rack and portable models, with one or two channels. Sold by dealers.



MODEL 3200 *Magnetic Tape Duplicator*
High speed duplication, with superb fidelity, of recorded master tapes. Makes up to 10 copies at one time. Available with one, two or four channel heads.

Fully illustrated brochures, complete with specifications, are available on each recorder and the duplicator. Technical bulletins are also available on the following subjects: VIDEOTAPE RECORDING • VIDEOTAPE SPLICING • MULTI-CHANNEL RECORDING • MULTI-CHANNEL TECHNIQUES • Write for the copies you want, today.

Tenth Year of Leadership

AMPEX CORPORATION
professional products division

934 CHARTER STREET, REDWOOD CITY, CALIFORNIA

*TM Ampex Corporation

Record of National Symposium on Extended Range and Space Communications

By E. R. S. C. Symposium Committee of the Institute of Radio Engineers, Washington, D.C. Published by the Goetz Company, 1030 20th St., N.W., Washington 6, D.C., 119 pp. Illus. i–iii.

Under the joint sponsorship of the Institute of Radio Engineers and George Washington University, the symposium recorded in this 119-page booklet was held in Washington in October 1958. Eighteen papers were presented in five sessions, covering the general topics of space transmission problems, meteor burst communications systems, transoceanic communication by means of satellites, extended range tropospheric communication systems, and extended range ionospheric communication systems.

An introductory survey paper by Maj. Edward N. Wright, of the Air Research and Development Command, describes the requirements for communications of the Air Force, and explains some of the special problems resulting from the extension of communication channels into outer space.

Other papers in this volume present such subjects as the transmission of television signals from satellites, wideband facsimile transmission, meteor burst system performance, the use of satellites as communication relay stations, and various systems using scatter techniques.

For the communications engineer desiring a brief survey of recently developed approaches to many problems, this collection of papers will represent a valuable source of information.—*A. L. Sorem*, Eastman Kodak Co., Research Laboratories, Kodak Park, Rochester 4, N.Y.

Kodak Books and Guides 1959 (L-8) has been revised to include recent titles of publications on general and specific photographic subjects. The 16-page booklet gives a brief description of the publications, number of pages and price. It is available without charge from Eastman Kodak Co., Sales Service Div., Rochester 4, N.Y.

Journals Available/Wanted

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Issues beginning in 1953 available on a nominal basis. Write: Mitchell M. Badler, 1711 Davidson Ave., Bronx 53, N. Y.

Complete set of Transactions, except Nos. 6 and 9, and all Journals published to date, including indexes. All in good condition. Price $500. Also extra copies of Transactions Nos. 2, 3, 4, 5, 8, 21, 31, 32. W. W. Hennessy, RFD #2, Pound Ridge, N. Y.

Complete set of Journals from May 1937 to June 1954, including special volumes and membership directories, excellent condition; also Mar., May 1934 and July 1935 issues. Write: Harry R. Lubcke, 2443 Creston Way, Hollywood 28, Calif. HO 9-3266.

Jan.-Dec. 1950; Jan., Feb., Apr.-Dec. 1951; Jan.–Mar. 1952. Also available are vols. 6 and 7 of The Television Society (British) covering the period Jan. 1950 through Sept. 1955. Write: Andrew N. McClellan, 65 Hillside Drive, Toronto 6, Ont., Canada.

Dec. 1946, Feb.–Dec. 1947, 1948–1955 complete. All copies in perfect condition; for sale as entire lot only. Write: Joseph W. MacDonald, 2414 Sullivant Ave., Columbus 4, Ohio.

Jan. 1947 to Dec. 1957 complete and in perfect condition. For sale only as a set. Write: Charles J. Marshall, 2816 Royalston Ave., Kettering 19, Ohio.

Complete set of Journals Jan. 1949 to Dec. 1958. Perfect condition. What offers? Write: J. G. Jackson, 210 Kingsway South, Port Alberni, B.C., Canada.

All Journals June 1940 to Oct. 1958, except Aug. 1943, Jan., May, Nov., 1946, Dec. 1953. Write: David Waddell, 95 North St., Stoneham 80, Mass.

Feb. 1937; May–Dec. 1938; 1939–1943 complete, 1944 complete except for May; 1945 complete except for Jan.; 1946 complete; 1947 complete except for Apr., May, June; 1948 complete except for June; 1949–1950 complete; Jan., Feb., Mar. 1951; 1952 complete; Feb., Mar. 1953. Also Edison Home Kinetoscope in operating condition, with 4 reels of original film and 2 glass slides. Bill Straley, 123 Arroya Vista Dr., San Antonio 1, Texas.

Jan., Mar. 1958; Feb.–Apr., June–Sept., Dec. 1947; Jan., July–Oct., Dec. 1946; Feb. 1937; June 1936; Index 1936–45. Fine condition; $1 each. James G. Barrick, 1278 West 103 St., N. W., Cleveland 2, Ohio.

Assortment of Journals, from 1937 through 1950. Write: Alan Cook, South Londonderry, Vt.

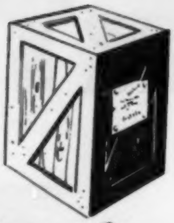
Wanted

Jan. 1938. E. Raymond Arn, Film Associates, Inc., 4600 S. Dixie Ave., Dayton 9, Ohio.

High-Speed Photography, Vols. 2 & 3. Morton Sultanoff, Terminal Ballistics Laboratory, Aberdeen Proving Ground, Md.

Jan. 1938, Jan. 1949. Dept. of Cinema, Univ. of Southern Calif., University Park, Los Angeles 7. Att: Herbert E. Farmer.

Transactions No. 1, 1916 ($5 offered); No. 6, 1918 ($10 offered); No. 7, 1918 ($10 offered). James G. Barrick, 1278 West 103 St., N.W., Cleveland 2, Ohio.



new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

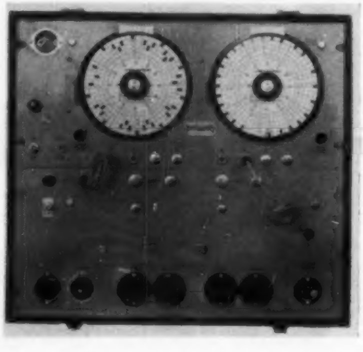
The Model S-305 Variable Band Pass Filter has been announced by Studio Electronics Corp., 711 S. Victory Blvd., Burbank, Calif. The new bandpass filter is for use in disk, tape and motion-picture sound recording applications and for industrial uses requiring the reduction of the audio bandwidth to predetermined limits. The rack-mounted unit features two separate key switches to permit insertion of low-frequency and/or high-frequency filter sections independently, at whatever time and whatever cutoff frequency is desired. Normalled input and output jacks are also provided. Selector switches permit choice of any of 15 low-frequency cutoff points, for 30 to 200 cycles and any of 15 high-frequency points from 2 to 15 kc.

Studio Electronics Corp. also recently announced an improved program equalizer for motion-picture recording and TV use. It has output and input impedances of 600 ohms and an insertion loss of 14 db, provides up to 16-db attenuation and 12-db boost at 40 to 100 cycles, and at 3, 5, 7, 10 and 15 kc. The unit is provided on a standard rack panel; or component parts and dials may be purchased separately. The equalizer is designed for insertion in individual microphone or program circuits.

The 3-MAN-8 Octave Band Equalizer and Noise Source has been announced by Allison Laboratories, Inc., 14185 Skyline Dr., La Puente, Calif. Each band can be adjusted for level to simulate a given environmental noise spectrum. The unit incorporates a white noise generator and amplifiers and will supply signals for low-frequency and high-frequency power amplifiers. The Octave Band Filters are passive networks with hum-bucking construction. They have an attenuation rate of 40 db/octave. The spectrum coverage is from 20 to 9600 c with provision for a ninth band 9600 to 19,200 c. The noise generator can be set for constant energy per cycle or for constant energy per octave.

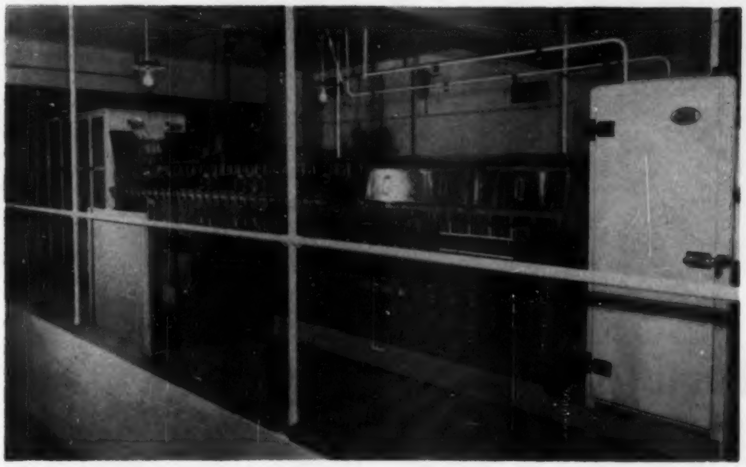
Power-supply accessories featuring improved Duratrak control-surface 10-amp Variac adjustable autotransformers and direct-reading metered models are manufactured by General Radio Co., West Concord, Mass. The company has also announced a line-voltage regulator, Type 1570–AS25, designed to meet military environmental requirements of shock, vibration, temperature and humidity. The regulator is servo-controlled and for 3-phase service.

A new magnetic sound recording tape has been announced by the Harwald Co. Its guaranteed minimum signal-to-noise ratio in presence of high-frequency bias is 55 db. It requires an erasing field of 1000 oersteds. The new tape is available on standard 1200-ft reels with 6-spoke design to eliminate warping. At usual running speeds, its output uniformity is said to vary less than 0.5 db within the reel, and less than 1 db from roll to roll. Specifications are in conformity with U.S. Navy Specification WT-0061. For details and prices, write The Harwald Co., Dept. 45, 1245 Chicago Ave., Evanston, Ill.



The CECO Programmer, Model 640A, an interval timer designed mainly for scientific and industrial research, can turn three separate electric loads on and off at times predetermined by the user; thus, three different on-and-off programs can be set up. A fourth program, consisting of momentary closings of a switch at predetermined times, is provided for. This is especially useful for operating time-lapse motion-picture cameras or synchronized-flash still cameras. Further information is available from Camera Equipment Co., 315 W. 43 St., New York 36.

The Cinetron IV, a color temperature control unit, has been announced by Forney Films, Cinetron Div., 1802 LaPorte Ave., Fort Collins, Colo. It is available for either 460-v or 230-v current and is equipped with six 30-amp rated output receptacles and six-position Ohmite selector switches. The 140-lb unit is designed to meet requirements of photographic assignments using ordinary lamps. Thirty-amp circuit breakers are used on the outlets with a 90-amp breaker on 230-v input or 50-amp breaker on 460-v input. Two General Electric meters show line draw and input voltage. A Simpson Kelibrator meter shows color temperature on any of the six outlets and selector switches permit balancing or blending of light clusters at temperatures up to 3400 K.



A daylight processing machine for 16mm Ektachrome has been designed by Rank Laboratories, Denham, England, and is now in operation. The new machine forms one side of a double-sided machine; the other side is for processing Eastman Color. The machine is built on two floors with the solution tanks, pumps and plumbing below the processing tanks. It has an output of 50 ft/min. The film magazines, take-off and elevator and, at the other end, drying cabinet and take-up are standard Arri equipment supplied by G. B-Kallee. The processing equipment was built in the laboratory workshops.

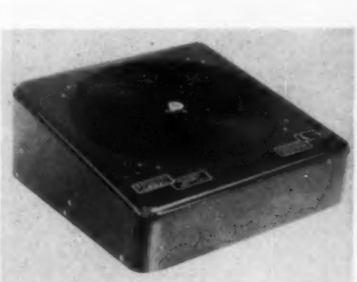
In the first tank following the elevator, the film is wetted with developer as a preliminary to a buffer roller in the second tank which removes the antihalation backing under a water spray. Four tanks provide first development (black-and-white) which takes 6¼ min. A rinse tank is followed by a hardening bath. The second exposure takes place in a washing tank under the surface of the water. One side of the tank consists of a glass window through which the moving film is exposed to the light of eight lamps.

In the next four tanks the process of color development is carried out. The developer is sprayed upon the submerged film and the upper rollers are below the surface of the solution. The film then goes through two washing tanks, a second hardener bath, another wash and then bleaching. This is followed by the final washing, stabilization and drying. Before entering the drying cabinet, the film passes through an air knife. The tanks are constructed of plastic and the pipes are of Duropipe.

Solutions including washing water are maintained at a constant temperature of 80 F by means of warm water circulating through coils in the tanks. Temperature of developers is controlled by an electronic thermostat.

First production unit of a magnetic disk recording system developed by Radio Corp. of America for radio broadcasting has been delivered to station WDAS, Philadelphia. The magnetic disks, designed to facilitate recording and playback of commercial announcements and similar radio material, may be erased and reused. In testing, the disks were replayed 10,000 times and report without detectable wear or loss of quality.

A transistorized plug-in preamplifier designed for audio and instrumentation applications has been announced by Hallen Electronics, Division of Schoen Products, 332 N. LaBrea Ave., Los Angeles. Of modular construction, the unit is 1⅞ in. square, 2⅞ in. high, and operates from a 24-v power source. Designed for amplification of any low-level signal from a low-impedance source, the preamplifier supplies a maximum gain of 60 db for flat response. The signal-to-noise ratio is reported below 70 db, with frequency response from 7 c to 30 kc.



A semiautomatic Turntable Degausser, Model A-937, featuring a predetermined 20-sec timed cycle, has been announced by Magnasync Mfg. Co., 5546 Satsuma Ave., North Hollywood, Calif. It is designed to accommodate all sizes of instrumentation tapes and magnetic films. It is priced at $159.50.

Twenty-one large seamless projection screens have been manufactured by the Stewart-Trans-Lux Corp., Torrance, Calif., under government contract for use at the American Exhibit in Moscow. Seven screens, each 20 ft high and 30 ft long are

installed in the huge geodesic dome building. Eleven screens are installed in the Circarama building. The screens are of the Ultramatte type selected because of brilliance and viewing angle characteristics.

A 70mm projector alignment film, prepared by the Motion Picture Research Council, Inc., 6660 Santa Monica Blvd., Hollywood 38, as a result of the present availability of 70 – 35mm projectors can be used to check aperture dimensions which are or may be in use. The film can also be used to judge jump and weave, and to check travel ghost, focus and buckling. The film is available from the Motion Picture Research Council under Code No. PA-70. It is priced at 47 cents per ft at a minimum length of 100 ft, or in increments of 100 ft up to a maximum of 600 ft.

A tripod head called CECO Pro Jr. Fluid Head has been introduced by Camera Equipment Co., 315 W. 43 St., New York 36. The 8½ lb head uses a highly molecular silicone polymer which is unaffected by temperature ranges from −20 F to about 120 F. Pan and tilt chambers are placed horizontally to facilitate even distribution of fluid. The new head fits present Pro Jr. bases and accessories and will accommodate the following cameras: Auricon Cine-Voice (100 ft or converted for 400 ft); Arriflex 16 and 35; Maurer 16mm; Kodak Cine-Special; Bolex 16mm; Bell & Howell Filmo and Eyemo 35mm, and

Eclair Camerette. Features include adjustable tension on pan and tilt; maximum 90° tilt, and two-place pan handle with infinite adjustment. It is priced at $300.00.

Products of Miller Professional Equipment Co. of Sydney, Australia, will be handled by Florman & Babb, Inc., 68 W. 45 St., New York, recently appointed exclusive East Coast distributor. Two new Miller Fluid Head Tripods have been announced, the Model D, medium weight, to accommodate all "hand" cameras, including Filmo, Cine Special, Arriflex 16, Bolex, Cine Voice, Auricon, etc. It is priced at $150.00. A swivel base for fast leveling is available for this model, priced at $59.50. The Professional, heavy duty model, will handle larger cameras, such as Mitchell 16, Maurer, Super 600 and 1200 Auricon, Filmo, Cine Special with motors and magazines, and the Arriflex 16 or 35 with magazines. It is priced at $299.50.

The S.O.S. Versa-Dolly has been announced by S.O.S. Cinema Supply Corp., 602 W. 52 St., New York 19. The device is a combination dolly with clamps, baby tripod triangle with clamps, and baby legs tripod. Used as a dolly with clamps it can be used for low tracking dolly shots only 12 in. off the ground and supports medium weight 16mm cameras and tripods. As a tripod triangle with clamps, it extends from 37 in. to 56 in. and holds heavy tripods and camera firmly clamped. Used as a baby tripod, it is only 17 in. high. It is priced at $99.50.

A lightweight (56-lb) TV camera, the Marconi Broadcast Vidicon camera channel Type BD864, has been introduced by Marconi's Wireless Telegraph Co., Chelmsford, Essex. Printed circuits are employed to achieve overall size of 14½ in. high, 15 in. long, and 10¼ in. wide. The camera channel consists of two units, the camera and the power supply/termination unit. The camera is self-contained and incorporates all operating controls in addition to a 7-in. picture display and 2¾-in. waveform display. A 1-in. English Electric Valve Co. vidicon forms the "eye" of the camera. A four-position turret is used with provision for mounting a wide range of lenses or a zoom-type lens. Designed for quiet operation, an indexing mechanism gives a silent and rapid lens change.

A mobile television studio and videotape unit for production of TV commercials and feature programs has been announced by Termini Video Tape Services, Inc., 1440 Broadway, New York 18. The equipment is transported in two 1959 Ford Trucks, specially designed by RCA Broadcast and Television Equipment Div. One truck contains a TV studio with three RCA cameras designed for field work. The equipment includes a Zoomar lens, switching system, and audio system. An image orthicon is employed to overcome poor lighting conditions. Included in this truck is a stabilizing amplifier, an 8-channel

NEW

Houston Fearless

Color Labmaster

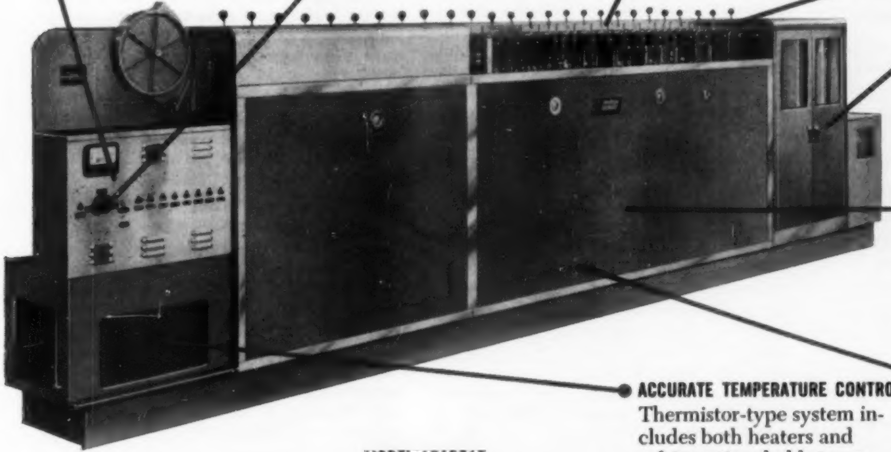
Faster! Better! Easier! Color Film Processing

SIMPLIFIED OPERATION
Automatic controls minimize need for personal supervision. Requires minimum of training.

ELECTRONIC SPEED CONTROL
Film transport speed control is provided by variac regulation of motor for greater accuracy.

UNIFORM FILM TENSION
Exclusive H-F clutch drive maintains uniform film tension, eliminates film breaks.

ADJUSTABLE LIFTER RODS
Indicate position of elevator in each tank, permit fine adjustment of time in solutions.



EFFICIENT DRY BOX
Utilizes filtered air warmed by fin-strip heaters. Adjustable to low, medium & high.

STAINLESS STEEL TANKS
All tanks are type 316 stainless steel with bottom drains. Accurate temperature indication provided.

ACCURATE TEMPERATURE CONTROL
Thermistor-type system includes both heaters and refrigeration, holds temp. to within $\pm 1/4°$

TURBULATION PUMPS
Developer and bleach tanks have turbulent washes. Pumps are chemical-resistant, trouble-free.

MODEL 16ARC15

COMPLETE AUTOMATION of color film processing is accomplished with the NEW Houston Fearless Color Labmaster . . . making it possible to process more film in less time — with less personal supervision — and assuring consistently high quality results. Available in three basic models: For 16mm Ektachrome (7255) and Anscochrome; 16mm Anscochrome; 16/35mm Anscochrome. Processing speeds up to 35 feet per minute.

Completely self-contained, daylight operating. Highly experienced engineering, the finest available materials and precision craftsmanship produce a rugged, efficient, thoroughly dependable machine. Volume manufacturing permits pricing the Color Labmaster most reasonably. Send coupon now for catalog and prices. *For 31 years Houston Fearless has been the leading manufacturer of motion picture film processors, your assurance of parts and service availability.*

HOUSTON FEARLESS

HOUSTON FEARLESS CORPORATION
11827 West Olympic Blvd., Los Angeles 64, California
Send catalogs and prices on ☐ Color Labmaster processors. ☐ B & W processors. ☐ Camera heads. ☐ Remote Control heads. ☐ Tripods. ☐ Dollies. ☐ Pedestals.

Name____________________
Firm____________________
Address____________________
City__________ Zone____ State______

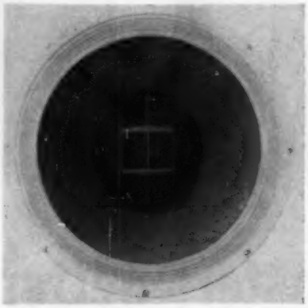
audio mixer, remote mixing audio facilities, roof mounts for the cameras, two line monitors and one preview monitor. Other features include a Telechrome Model 490A Special Effects Generator; $\frac{1}{4}$-in. Ampex Tape Recorder, and a turntable. The second truck houses the Ampex VR-1000 Tape Recorder. This also has a stabilizing amplifier, as well as automatic gain control into the Ampex machine, a waveform analyzer, video patch system and editing facilities. The two trucks can be used separately, although planned mainly for use as an integrated team. There are record and playback facilities between trucks; intercommunication between the control truck and the cameras and between the control truck and the stage area.

For rent: a mobile video-tape recording unit, now under construction, will be available to advertisers, agencies, TV stations and independent film producers, according to an announcement by Giantview Television Network, 901 Livernois, Ferndale 20, Mich. The unit, designed for shooting taped commercials and features on location, will comprise an Ampex Videotape Recorder, four studio image-orthicon cameras, a complement of 20 lenses including zoom-type, a TV film recording unit, audio recording facilities, and other auxiliary facilities. It will be mounted on a specially designed truck trailer.

Military and civilian jet flights were shown daily over closed-circuit TV in the Las Vegas Convention Auditorium as part of the first World Congress of Flight held in Las Vegas April 13–19. Shown were demonstrations of jet and other aircraft. Pickup and feed for the closed circuit were supplied by NBC. Large-screen projection was by Pembrex Theatre Supply Co., West Coast affiliate of Giantview Television Network. Three Commercial Picture Equipment screens were placed in a horseshoe-shaped arrangement to afford the best view to all seats in the semicircular arena. The Congress was sponsored by the Air Force Association.

A new television station is under construction at Recife, Pernambuco, Brazil. It is expected to be in operation early in 1960. Transmitting and studio equipment is being supplied by Marconi's Wireless Telegraph Co., Chelmsford, Essex.

Two new Oxberry animation stands have been announced by Animation Equipment Corp., 38 Hudson St., New Rochelle, N.Y. Model FS-4300 is designed for high-speed slide-film-strip production. Features include autofocus combined with automatic rackover and lamp to allow projection of the reticle onto the table top for quick positioning of artwork up to 35 in. Included in the purchase price of $9100 is the Oxberry 35mm camera, including viewfinder, fixed pin registration, 47mm lens, 400-ft magazine, automatic take-up and single-speed stop-motion motor. Model MP-4200 is designed as a "complete package for animation studios." The table top measures 28 by 34 in. Two 12-field peg tracks are included, handwheel controlled, with counters and locks. It is priced at $10,200.



A new Duplex speaker with controlled linear excursion has been announced by Altec Lansing Corp., Anaheim, Calif. The new model, 605A, replaces the 604D. Improvements have been made in both the bass and treble sections. In the bass section the new speaker has high-compliance suspension components for controlled linear excursion, stress-free assembly for ultimate linearity of the suspension system, a voice coil confined to a uniform magnetic field, and a low cone resonance of 25 cycles for reproduction of the lowest bass notes. Treble section improvements include a lighter voice coil, higher acoustic transformation and smoother high-end response. The new speaker is priced at $175.00.

A new capacitor has been announced by Packard Bell Electronics Corp., 12333 W. Olympic Blvd., Los Angeles 64. The capacitor is made of ceramic in two forms, extruded and molded. The extruded model is a tube with a triangular cross bracing which performs double duty as a structural core and as a surface area to increase capacitance. The molded type is of solid construction which may be manufactured automatically in one piece without the use of leads or terminals. Both types are suitable for high temperature. The molded type is capable of withstanding extreme temperatures due to its elimination of solid terminals.

A coin-operated machine which tests driving ability consists of an automobile dashboard, steering wheel, brakes and gas pedals plus a motion-picture screen placed in front of the driver. The screen shows traffic conditions through which the driver must guide his car. He is automatically scored on his ability to accelerate, brake and steer smoothly and safely. Capitol Projector Corp. and Standard Financial Corp., both of New York, have arranged for sales and financing of the machine.

Lasticolor, a vinyl spray said to impregnate fabrics and synthetics with a lasting vinyl coating in a choice of 14 mix-or-match shades, has been announced by Taussig Paint Sales Co., Old York Rd. & Township Line, Jenkintown, Pa., near Philadelphia. The announcment noted that the spray can be useful in theater redecorating to "refurbish the seats and drapes," and to "get extra mileage from stage props in the living theater."

The Vallen Rear Fold Track, Model 152A, a product of Vallen, Inc., Akron 4, Ohio, is a track that turns the curtain at right angles and folds it along the side walls. The device is recommended for small stages, industrial displays, etc., where curtain storage space is limited.

High-precision machine parts are described in profusion in a new 12-page brochure available from LaVezzi Machine Works, 4635 West Lake St., Chicago 44. The company specializes in producing for equipment manufacturers fine machine parts on order, such as Geneva starwheels, film sprockets, film traps, gears, face clutches and assemblies.

The 13.6 Special Large-Cored Carbon for 35/70mm projection is a product of Lorraine Orlux Carbons, Boonton, N.J. The new carbon is reported to maintain a constant intensity and uniform distribution of light over the screen area and to be usable with new projectors such as Victoria-X 35/70; National Bauer 35/70; Phillips 35/70; Century 35/70 and Modified Simplex X1.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Projectionist. 19 yrs experience in booth operation and theatre projection. Experienced with 70mm, 35mm and 16mm—optical and magnetic sound—indoor and drive-in theatres. Age 37, single. Desires position with foreign service. Member IATSE and SMPTE. Write: E. O. Hepler, Jr., 15 Morningside Drive, Boonville, Mo.

Motion Picture Production. Extremely creative, energetic. 7 yrs heavy experience in film production, studio and location, educational, industrial and TV films. Created, photographed and edited 22 TV commercials for one of America's top toy companies. Desires position with Ad Agency, live studio or TV Station. Age 26, Vet and Single. Willing to travel throughout the world. Resume and references on request. Write FILM, 3738 Cypress Ave., Brooklyn 24, N.Y.

Motion-Picture or Television Production. Graduate New York Univ., B.A. Communication Arts. Experienced all phases motion-picture and television production. Seeking permanent position with television or motion-picture production organization. Willing to relocate. Résumé on request. Write: Walter Bleich, 2700 Marion Ave., New York 58.

Assistant to Director or Producer. Former instructor in motion pictures, Theater Arts Dept., Univ. of California, Los Angeles, desires position as personal assistant to a director or producer of feature films. Background includes: B.A. in Motion Pictures, 3 years teaching all phases of motion-picture production, second unit direction of a Disney "true-life adventure," and director of photography on dramatic and documentary films. Willing to travel. Available for interview in Los Angeles area. For references and detailed résumé write: William R. Lieb, 140½ W. Foothill Blvd., Claremont, Calif. Tel: NAtional 4-4166.

Editor-Cameraman. Over 10 yrs solid production experience in New York with quality producers of industrial, business and television films. Seek staff position. Résumé available. Member SMPTE since 1948. No other affiliations. Joe M. Wolff, 43-31 Ithaca St., Elmhurst, N.Y.

Motion Picture Cameraman, Technician. 7 years actively engaged in 16mm motion-picture work. For the last 4 yrs have been employed as head of technical operations of a company producing films primarily for TV and educational usage. Experience includes work in practically every technical phase of motion-picture production. Desire connection with a producer of industrial, education, scientific or travel films. Age 30 and an active member of SMPTE. Résumé on request. G. Kenneth Futrell, 678 Pope Street, Memphis 12, Tenn.

Engineering Aide. 32 yrs talkies, radio, audio, magnetic tape, intercom. Attending night school for degree. Desires R&D position with sound or cine organization. Salary $2.35 per hour. Teachable, studious, no drink or smoke. Los Angeles only. Frank W. Mango, 1211 N. Berendo St., Los Angeles 29.

Audio-Visual Aids Specialist. Six yrs experience full-time with City of N. Y. in the City Colleges and 3½ yrs as supervising technician at Columbia Univ. and NYU. Matriculated university student with courses in cinematography, motion-picture production and its history. Considerable experience with operation of 16mm sound projectors, operation and service of filmstrip and slide projectors, professional tape recorders. Demonstration of audio-visual equipment to prospective teachers or college faculty and students. Richard I. King, 270 Convent Ave., Apt. 8E, New York 31. WA 6-1910.

Laboratory Contact/Optical Printing Specialist. Past 6 years under contract Consolidated Labs east coast as head of unit. 20 yrs prior employment with Universal, Paramount, Warners in Hollywood on camera. Ideal to destroy phonies. Own optical printer using Acme camera, projector, etc., for 35/35; 16/16, 35/16, 16/35, color or black-and-white, plus contact registration and aerial image — for rental or sale. Bill Heckler, 21 West 58 St., New York 19. PLaza 3-7067.

Positions Available

Editor-Cameraman, for 4-man educational film unit. Requirements: 4 yrs experience or 4 yrs college major in cinema plus 2 yrs experience. Primary duties in all phases of editing; secondary duties as assistant to first cameraman. Modern equipment. Starting salary $5160 a year. Send résumé and references to Leonard Pullen, Acting Production Supervisor, V.P.I. Motion Picture Unit, Virginia Polytechnic Institute, Blacksburg, Va.

Writer-Director, for 4-man educational film unit. Requirements: 4 yrs experience or 4 years college major in cinema plus 2 yrs experience. Duties: research subject matter, all phases scripting, direct action during shooting. Starting salary $5160 year. Send résumé and references to Leonard Pullen, Acting Production Supervisor, V.P.I. Motion Picture Unit, Virginia Polytechnic Institute, Blacksburg, Va.

Film Inspectors. Temporary or permanent. Write or call Peerless Film Processing Corp., 165 W. 46 St., N. Y. 36. Tel. PLaza 7-3630. Att: Kern Moyse.

Cinematographers to assume responsibility for current motion-picture projects in military sales promotion, R & D film progress reports, public relations, etc. Three yrs experience as senior motion-picture cameraman needed. **Senior Motion-Picture Film Editor** responsible for editing completely integrated motion pictures including sound if required. Three yrs practical experience as editor required. Send complete resumes to R. C. Dunnuck, Engineering Personnel, North American Aviation, Inc., 4300 East Fifth Ave., Columbus 16, Ohio.

Motion-Picture Laboratory Printing Room Night Supervisor to oversee production problems and rates. Must be completely familiar with laboratory printing operation. Salary open. Contact Robert Crane, Color Service Co., Inc., 115 West 45 St., New York 36. JUdson 6-0853.

Chief Engineer. Immediate opening. Responsibilities include the administration of a staff of engineers designing electro-mechanical products for commercial and military application. Located in the Los Angeles area. Please reply in writing to W. C. Heath Associates, Inc., Room 526, 714 West Olympic Blvd., Los Angeles 15, Calif.

Audio Repair Man. Thoroughly experienced on magnetic tape recorders, projector and Moviola amplifiers, etc. Knowledge of motion-picture sound equipment essential. Good salary. Write fully to Arthur Florman, Florman & Babb, Inc., 68 West 45 St., New York 36.

Motion-Picture Equipment Salesman. Knowledge of all professional production equipment. Outside sales, to visit film producers, industrial accounts, etc. Fully exerienced. Good salary. Write fully to Arthur Florman, Florman & Babb, Inc., 68 West 45 St., New York 36.

Recording Engineer. To serve as head of electroacoustics laboratory involving duties in the fields of audio-video, acoustics and recording systems. Must be able to render consultation services in connection with research and development on related electronic systems and programs. Degree plus 3 yrs professional experience in above fields required. Salary $8810 per annum. Position is in Federal Career Service. Send SF-57 "Application for Federal Employment," obtainable at any Post Office, to Employment Superintendent, U. S. Naval Training Device Center, Port Washington, N.Y.

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Meeting Calendar

National Audio-Visual Association Convention and Exhibit, July 25–28, Morrison Hotel, Chicago.

Society of Photographic Instrumentation Engineers, National Meeting, Aug. 4–7, Ambassador Hotel, Los Angeles.

WESCON, Aug. 18–21, Cow Palace, San Francisco.

AIEE, Petroleum Industry Conference, Aug. 25–27, Wilton Hotel, Long Beach, Calif.

Mathematical Association of America, Summer Meeting, Aug. 31–Sept. 3, Univ. of Utah, Salt Lake City, Utah.

New York State Society of Professional Engineers, Autumn Meeting, September, Niagara Falls, N. Y.

Illuminating Engineering Society, Annual National Conference, Sept. 7–11, Fairmont & Mark Hopkins Hotels, San Francisco.

American Institute of Electrical Engineers and National Electrical Manufacturers Association, National Electrical Insulation Conference, Sept. 9–11, Chicago, Ill.

Society of Plastics Industry, Midwest Section Conference, Sept. 10, 11, French Lick, Sheraton Hotel, French Lick, Ind.

American Chemical Society, National Meeting, Sept. 13–18, Atlantic City, N.J.

Standards Engineers Society, Annual Meeting, Sept. 21–23, Somerset Hotel, Boston, Mass.

Instrument Society of America, Annual Instrument-Automation Conference and Exhibit, Sept. 21–25, International Amphitheatre, Chicago, Ill.

IRE, Conference on Non-Linear Magnetics and Magnetic Amplifiers, Sept. 23–25, Shoreham Hotel, Washington, D.C.

AICE, Sept. 27–30, St. Paul Hotel, St. Paul, Minn.

National Symposium on Telemetering, Sept. 28–30, Civic Auditorium and Whitcomb Hotel, San Francisco.

IRE and AIEE, Industrial Electronics Conference, Sept. 30–Oct. 2, Muelbach Hotel, Kansas City, Mo.

IRE, Aeronautical Communications Symposium, Oct. 5–7, Hotel Utica, Utica, N. Y.

86th Semiannual Convention of the SMPTE including Equipment Exhibit, Oct. 5–9, Statler Hilton Hotel, New York.

IRE Canadian Convention, Oct. 7–9, Toronto, Ont.

Optical Society of America, Annual Meeting, Oct. 8–10, Chateau Laurier Hotel, Ottawa, Ont.

ASCE, Los Angeles Convention, Oct. 9–13, Hotel Statler, Los Angeles.

AIEE, Fall General Meeting, Oct. 11–16, Chicago.

National Electronics Conference, Oct. 12–14, Hotel Sherman, Chicago.

National Society of Professional Engineers, Fall Meeting, Oct. 15–17, Olympic Hotel, Seattle, Wash.

ASCE, Annual Convention, Oct 19–23, Hotel Statler, Washington, D. C.

American Standards Association, National Conference on Standards, Oct. 20–22, Sheraton-Cadillac Hotel, Detroit, Mich.

Acoustical Society of America, Fall Meeting, Oct. 22–24, Wade Park Manor Hotel, Cleveland, Ohio.

Society of Photographic Scientists and Engineers, Oct. 26–30, Edgewater Beach Hotel, Chicago.

IRE, Electron Devices Meeting, Oct. 29–31, Shoreham Hotel, Washington, D. C.

Louisiana Polytechnic Institute, Instrumentation Conference, Nov. 5, 6, Ruston, La.

IRE, Instrumentation Conference, Nov. 9–11, Atlanta, Ga.

Sixth National Symposium on Reliability and Quality Control, Jan. 11–13, 1960, Statler Hilton Hotel, Washington, D.C.

IRE National Convention, Mar. 21–24, 1960, Coliseum and Waldorf-Astoria Hotel, New York.

87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles.

88th Semiannual Convention of the SMPTE, and

Fifth International High-Speed Congress and Equipment Exhibit, Oct. 16–22, 1960, Sheraton-Park Hotel, Washington, D.C.

89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.

90th Semiannual Convention of the SMPTE, Oct. 15–20, 1961, New York.

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SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1958 Journal, Part II.

sustaining members

of the Society of Motion Picture and Television Engineers

The objectives of the Society are:

- Advance in the theory and practice of engineering in motion pictures, television and the allied arts and sciences;
- Standardization of equipment and practices employed therein;
- Maintenance of high professional standing among its members;
- Guidance of students and the attainment of high standards of education;
- Dissemination of scientific knowledge by publication.

Progress toward the attainment of these objectives is greatly aided by the financial support provided by the member companies listed below.

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The Society invites applications for Sustaining Membership from other interested companies. Information may be obtained from the Chairman of the Sustaining Membership Committee, Byron Roudabush, c/o Byron Motion Pictures, Inc., 1226 Wisconsin Ave., N.W., Washington 7, D.C.